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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See page 17, Jan. 2. 7363

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Specification and Workmanship equal to Main Line Locomotives.
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See page 15, Jan. 2. 7454

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See Advertisement page 113.

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See Advertisement page 28. 7268

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See Illus. Advt. last week, page 15. 7977

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See Advertisement page 91, Jan. 2. 7402

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PRESSED STEEL WORK OF ALL KINDS.
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See half-page Advertisement pages 69, Dec. 26.

See Advt. Page 26, Jan. 2.
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For the prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
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(Registered under the Trade Union Act.)

An Association specially formed to look after the interests of Foremen on their Supervisory Capacity. C 509

All communications to— H. W. RHID, General Secretary. Head Offices— 81, High Holborn London, W.C.1.

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AN INSTITUTION FOR STRUCTURAL ENGINEERS, ARCHITECTS, &c.

EXAMINATIONS for GRADUATESHIP and for ASSOCIATE-MEMBERSHIP will be held at the offices of the Institute on 13th and 14th MAY, 1920. Forms of application and full particulars may be obtained from the SECRETARY, Denison House, 296, Vauxhall Bridge Road, London, S.W. 1. C 658

Imperial College of Science AND TECHNOLOGY, South Kensington, S.W. 7.

DEPARTMENT OF TECHNICAL OPTICS.

The following LECTURE COURSES will be given in the SPRING SESSION by Professor A. F. C. Pollard:—

Strength of Materials and Machine and Instrument Drawing.
FRIDAYS at Three p.m., commencing on JANUARY 16th, 1920.

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SPECIAL COURSES OF EVENING LECTURES
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II. REFRACTORY MATERIALS, by Professor J. W. Cobb, C.B.E., B.Sc., F.I.C.
III. METALLURGY (lectures and practical work), by Mr. P. F. Summers, A.R.S.M.
The Laboratory of the Department will be open on Wednesday Evenings for students desiring instruction in Fuel Calorimetry and Pyrometry.
For further information apply to The Secretary, The University, Leeds. C 774

Civil Service Commission.

FORTHCOMING EXAMINATION.

ASSISTANT EXAMINERS IN THE PATENT OFFICE (30-30), 4th March.
The date specified is the latest at which applications can be received. They must be made on forms to be obtained, with particulars, from the SECRETARY, Civil Service Commission, Burlington Gardens, London, W. 1. C 668

Inst. C.E. Exams.—Over 300

successes by Correspondence Coaching. Several prizes. Sec. "O" now prepared. (Designs, Specifications and Quantities). A few vacancies open.—Address, 7434 Offices of Engineering.

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and all Engineering Examinations.—Mr. G. F. KNOWLES, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. 8073

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Tuition. Also Postal Courses in Mechanical Engineering, Aircraft Design and Mathematics.—PENNINGTONS, 264, Oxford Road, Manchester.

TENDERS.

ROYAL SIAMESE STATE RAILWAYS.

RAILS AND ACCESSORIES.

Tenderers are Informed that

the date for handing in Tenders has been postponed to March 15th, 1920. Those who have already mailed their offers are at liberty to submit a second tender.
F.O.B. Tenders will be considered.
By Order of the Commissioner-General,
Royal Siamese State Railways,
O. P. SANDBERG,
Consulting Engineers.
40, Grosvenor Gardens,
London, S.W.1. C 699

AUCKLAND HARBOUR BOARD, NEW ZEALAND.

Tenders are Invited for the

SUPPLY and DELIVERY of TWELVE (12) Five-ton (and alternatively for Three-ton) SEMI-PORTAL, BALANCED-JIB, LEVEL-LUFFING ELECTRIC CRANES.
Specifications can be obtained at the Office of Board's Agents on payment of a deposit (returnable) of Two Guineas. Drawings can be seen only at the Office of the Board's Agents:
Messrs. W. & A. McARTHUR, Ltd., 18-19, Silk Street, Cripplegate, London, E.C. 2.
Tenders to reach Auckland by noon on Sept. 1st, 1920, addressed, The CHAIRMAN, Harbour Board, Auckland, New Zealand. C 444

METROPOLITAN BOROUGH OF HAMMERSMITH.

ELECTRICITY DEPARTMENT.

SUPPLY OF REFRACTORY MATERIALS.

The Council Invite

Tenders for the following:—

Materials required for Boiler setting and Furnace work, viz.:—
(i) Supply and delivery only of Refractory Insulating, and ordinary Brickwork, and materials; or
(ii) Supplying, as in (i), and executing the necessary work required in setting a class 32/18 Stirling Boiler; or
(iii) Executing the work, as in (ii), only, without supplying the necessary materials.
Specifications and Forms of Tender may be obtained from Mr. G. G. BELL, Borough Electrical Engineer, Electricity Department, 85, Fulham Palace Road, W. 6.
Sealed Tenders, endorsed "Tenders for Refractory Materials," must be delivered to the undersigned not later than Ten a.m. on Tuesday, 20th January, 1920.
LESLIE GORDON, Town Clerk.
Town Hall, Hammersmith, W. 6.
6th January, 1920. C 767

G. R.

MINISTRY OF MUNITIONS.
BY DIRECTION OF THE DISPOSAL BOARD.
(Lands, Buildings and Factories Sections.)

For Sale by Tender.

GOVERNMENT CARTRIDGE FACTORY No. 3, Blackpole, Worcester.
To be SOLD by TENDER in One Lot, subject to certain conditions.
The following is a brief description:—
SITUATION.—About two miles N.E. of the City of Worcester, adjoining the Worcester and Birmingham Canal, with access from Blackpole Road. The nearest Goods and Passenger Station is Fernhill Heath (G.W.R.), about two miles distant, but there is a Passenger "Halt" at the Factory.
AREA OF LAND.—The total area of the property is about 68 acres, divided into two portions by the Great Western Railway (Oxford and Worcester Line). The land has been developed with roads, drains, sewers, at the expense of the Ministry, and these improvements are included in the Sale.
CONSTRUCTION.—The main buildings are mostly permanent and well built of brick with ruberoid or asbestos slate roofs. The subsidiary buildings are partly brick built, roofed with ruberoid, partly timber framed with ruberoid, asbestos slate and stellonite roofs.
The principal buildings comprise:—

	Floor Area Ft. Super.
Case and Bullet shop with offices and small buildings adjoining ...	86,332
Annealing shop with additions ...	19,273
Carpenter's shop, Power and Tractor houses	11,391
Boiler house	4,426
Canteen	16,226
Inspection and General Store, Loading Dock, and small additions	42,411
Main Shop	8,000

The remainder of the buildings include:—
Manager's Bungalow, Cycle Shed, Laundry, Stores, Female Dressing Rooms, Cap Factory, Magazines, etc.
Total floor area of buildings about 250,000 ft. super.
The buildings were erected by the Ministry in 1916-1917, and have been used for the manufacture of Small Arms Ammunition.
LIGHTING AND POWER.—Electric and Gas. Public Supply.
HEATING.—Low pressure steam shops, Electric offices.
WATER.—From Corporation Main.
SIDINGS.—Private sidings have been laid down and are connected with the main line.
CANAL.—The Worcester and Birmingham Canal passes along the south portion of the factory and affords good water facilities for traffic, and a loading wharf has been constructed for that purpose.
Forms of Tender; Conditions of Sale and Plan may be obtained on application to the CONTROLLER, Land and Factories Section, Disposal Board, Charing Cross Buildings, Embankment, London, W.C. 2.
Note.—For particulars of other Government Property for Sale, see *Surplus*, price 3d. at all bookstalls; or by quarterly subscription of 2s. post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. C 516

TO ENGINEERS AND OTHERS.

THE METROPOLITAN ASYLUMS BOARD Invite

Tenders for Providing and

Fixing HOT WATER SUPPLY APPARATUS at the Eastern Hospital, The Grove, Homerton, E. 9, in accordance with drawing and specification prepared by Mr. T. Cooper, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The drawing, specification and form of Tender may be inspected at the Office of the Board, Embankment, E.C. 4, on and after 10 a.m., Wednesday, 7th January, 1920, and the drawing, specification and form of Tender can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona fide* tender sent in accordance with the instructions on the form of Tender and after the specification and the drawing have been returned. Tenders addressed as noted on the form must be delivered at the Office of the Board not later than 2 p.m. on Wednesday, 21st January, 1920.
(By Order)
DUNCOMBE MANN, Clerk to the Board.
3rd January, 1920. C 726

G. R.

TWIN SCREW VESSELS FOR SALE.

WITHOUT RESTRICTIONS AS TO SALE ABROAD.

The Admiralty have for Dis-

POSAL H.M. TWIN SCREW VESSELS "BURY," "FAIRFIELD," "REPTON."
Boats are new and particulars are as follows:—

Length between perpendiculars ...	230 ft.
Breadth Moulded	28 ft. 6 in.
Depth Moulded to Upper Deck ...	16 ft. 3 in.
Coal carried, bunkers full	180 Tons.
Speed, full power, about	16 Knots.
Gross Tonnage, about	780

MAIN ENGINES.—Twin Screw, vertical, reciprocating triple expansion H.P. cylinder 13½ in. diameter, M.P. cylinder 21½ in. diameter. L.P. cylinder 34 in. diameter by 21 in. stroke.
I.H.P.—1100 each engine, 2200 total per ship. Revolutions, 270 per minute.
BOILERS.—Yarrow, small tube type, coal fired. Two in No. each vessel.
Tender Forms with permission to inspect may be obtained from the DIRECTOR OF CONTRACTS, Admiralty, Branch 8, Room 36, Avenue House, Northumberland Avenue, London, S.W. 1.
Tenders will be received up to TWELVE o'clock noon on Monday, 2nd February, 1920. C 656

CITY OF COVENTRY.

TRAMWAYS DEPARTMENT.

TENDERS FOR STEEL TRAMWAY RAILS.

The Tramways Committee of the Coventry Corporation invite

Tenders for the Supply and

DELIVERY, carriage paid, to the London and North Western Railway Station, Coventry, of 1000 tons of B.S. No. 4 STEEL TRAMWAY RAILS, at 105 lbs per yard. Specifications, Conditions and Forms of Tender may be obtained on application to Mr. T. R. Whitehead, General Manager and Engineer, Priestley's Bridge Depot, Coventry.
Tenders, stating the date of delivery, are to be addressed to the Chairman of the Tramways Committee, Priestley's Bridge Depot, Stoney Stanton Road, Coventry, and endorsed "Tramway Rails," not later than 10 a.m. on Tuesday, 20th January, 1920.
The Committee do not bind themselves to accept the lowest or any tender.
GEORGE SUTTON, Town Clerk.
Council House, Coventry,
30th December, 1919. C 607

CITY OF COVENTRY.

TRAMWAYS DEPARTMENT.

TENDERS FOR TRAMWAY GRANITE PAVING SETTS.

The Tramways Committee of the Coventry Corporation invite

Tenders for the Supply and

DELIVERY, carriage paid, to any of the London and North Western Railway goods yards, Coventry, as may be specified, of 6000 tons of Leicestershire, or equivalent, GRANITE PAVING SETTS, 4 in. wide by 5 in. deep.
Specification, Conditions and Forms of Tender may be obtained on application to Mr. T. R. Whitehead, General Manager and Engineer, Priestley's Bridge Depot, Coventry.
Tenders, stating the date of delivery, are to be addressed to the Chairman of the Tramways Committee, Priestley's Bridge Depot, Stoney Stanton Road, Coventry, and endorsed "Granite Setts," not later than 10 a.m., on Tuesday, 20th January, 1920.
The Committee do not bind themselves to accept the lowest or any Tender.
GEO. SUTTON, Town Clerk.
Council House, Coventry.
30th December, 1919. C 608

METROPOLITAN BOROUGH OF HAMMERSMITH.

ELECTRICITY DEPARTMENT.

WIRING OF SMALL PROPERTY.

The Council Desire to be

FURNISHED with PARTICULARS of WIRING SYSTEMS which Contractors are prepared to submit, suitable for property to be erected in connection with the Council's Housing Scheme.
Further particulars may be obtained on application to Mr. G. G. Bell, Borough Electrical Engineer, Electricity Department, 85, Fulham Palace Road, W. 6.
Propositions, which must be accompanied by a completely priced schedule for all necessary material, must be delivered to the undersigned, endorsed "Wiring Proposition," not later than Ten a.m., on Tuesday, 20th January, 1920.
LESLIE GORDON, Town Clerk.
Town Hall, Hammersmith, W. 6,
6th January, 1920. C 768

Tenders Required for Con-

STRUCTING, either in Steel or Reinforced Concrete a T JETTY, with frontage to the river of 300 ft. by 60 ft.; GANGWAY leading to same from face of existing premises, 65 ft. by 60 ft.
For further particulars apply to TRINITY WHARF C., Ltd., Rotherhithe, S.E. 16. C 736

COUNTY BOROUGH OF WEST HAM.

REFUSE DESTRUCTOR.

The Council hereby Invite

Tenders for the Supply and

ERECTION of a REFUSE DESTRUCTOR and STEAM-RAISING PLANT in connection with the Electricity Generating Station, Quadrant Street, Canning Town.
Site Plan, Specification, Form of Tender, and further particulars may be obtained at the Office of the Borough Engineer, Town Hall, West Ham, E. 15, upon payment of a deposit of £1, which will be returned upon receipt of a *bona fide* Tender.
Note.—No Tender will be considered unless the same is delivered at the Office of the Town Clerk, Town Hall, West Ham, E. 15, in the envelopes supplied, by registered post, not later than 4 o'clock p.m., on Tuesday, 24th February, 1920.
The Council do not bind themselves to accept the lowest or any Tender. The Contractor will be required to enter into a bond, with one surety, for the due performance of the Contract, and no work will be ordered under the Contract until such bond has been duly executed.
The Contractor, whose Tender is accepted, and with whom a Contract is entered into, will be required to pay the whole of his workmen such rate of wages, and observe such hours of labour, as are recognised by the Workmen's Trade Unions, and shall not assign, nor under-let, or make a sub-contract with any person or persons for the execution of any part of such work. In the event of any breach of such agreement the Council will enforce the penalty clause in its entirety.
By Order of the Council,
GEORGE H. HILLBARY, Town Clerk.
Town Hall, West Ham, E.
2nd January, 1920. C 715

APPOINTMENTS OPEN.

A Large Firm of Engineers

in the Midlands have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4359, Offices of Engineering.

WIGAN AND DISTRICT MINING AND TECHNICAL COLLEGE.

Wanted, Lecturer in Engi-

NEERING. Salary according to scale, Maximum £450, with possibility of subsequent increase to £540. Initial salary up to £300 according to qualifications and experience.—Further particulars may be had from the PRINCIPAL, to whom applications should be sent as early as possible. C 535

CITY OF BIRMINGHAM.

WATER DEPARTMENT.

APPOINTMENT OF SECRETARY.

The Water Committee invite

Applications for the Secretary-

SHIP of the Corporation Water Department. The person appointed will, subject to the control of the Water Committee, have charge of the commercial and financial side of the Department, and must have a sound commercial training with responsible experience in some large mercantile, manufacturing or water supply undertaking. He will be required to give his whole time to the duties of his office, and must not engage in private work of any kind. The appointment will be terminable by either party at any time on three months' notice.
The successful candidate will be required to contribute to the Corporation Superannuation Scheme.
Applications, stating age, salary required, present occupation and previous experience, should be sent, accompanied by copies of not more than three testimonials, addressed to—
THE CHAIRMAN, Water Committee, Council House, Birmingham.
Each application must be endorsed on the envelope "Appointment of Secretary," and must reach this office not later than noon, 30th January, 1920.
F. H. C. WILTSHIRE, Town Clerk.
Council House, Birmingham.
22nd December, 1919. C 545

UNIVERSITY OF LONDON.

Notice is Hereby Given that

the SENATE will proceed to ELECT EXTERNAL EXAMINERS for the Examinations, other than Medical, above Matriculation as follows:
For the year 1920—21:—
Mathematics.
For the year 1920:—
Engineering Mathematics. Electrical Technology.
N.B.—Attention is drawn to the provision of Statute 124, whereby the Senate is required, if practicable, to appoint at least one Examiner who is not a teacher of the University.
Particulars of the remuneration and duties can be obtained on application.
Candidates must send in their names to the External Registrar, GEO. F. GOODCHILD, M.A., B.Sc., with any attestation of their qualifications they may think desirable, on or before Monday, 26th January, 1920. (Envelopes should be marked "Examinership.")
It is particularly desired by the Senate that no application of any kind be made to its individual Members.
If testimonials are submitted, three copies at least of each should be sent. Original Testimonials should not be forwarded in any case. If more than one Examinership is applied for, a separate complete application, with copies of testimonials, if any, must be forwarded in respect of each. No special form of application is necessary.
University of London,
South Kensington,
S.W. 7.
January, 1920. C 742

SIMPLE STRESS DIAGRAM FOR ROLLING LOADS.

By NORMAN G. KAPP.

IN determining the stresses set up in the various members of a lattice girder under the influence of a rolling load, we imagine the load to be at various successive stages on the bridge and draw a stress diagram for these stages; the biggest stresses occurring are then picked out and added to the dead load stresses obtained from a separate diagram. The usual practice is to draw a fresh diagram for every position of the load. Each diagram contains the stresses for every member of the girder. For each diagram the reaction at the points of support must be calculated afresh. Now all these diagrams contain many quantities which are common to all, and the setting out of which constitutes mere repetition. There is, in fact, only one variable quantity, namely, the reaction at the supports. The load itself is constant.

A glance at the diagrams, Figs. 1 to 3, will make this clear. These, it should be stated, are all stress diagrams, it being unnecessary to give a figure of the actual truss itself, which is assumed to be a lattice girder of eight panels of 10 ft. each or a span of 80 ft. The wheel base of the rolling load is 5 ft., and the loads on the axles are 4 tons and 2 tons respectively. The equivalent load on a panel in the worst case will therefore be $4 + \frac{2 \times 5}{10} = 5$ tons on one end, and 1 ton on the other. These loads will appear on every panel in successive stages. AB represents 1 ton, BC represents 5 tons, CK is the reaction at the point of support to the left, KA the reaction at the point of support to the right. The diagram itself is the usual stress diagram and needs no further explanation. Now it will be seen from the Figs. 2 and 3, which represent the load at two further stages across the girder, that only the position of K varies, whilst AB and BC remain constant. Hence the lengths representing the various stresses vary, but the general character of the diagram remains unaltered. It will be observed that all the member stresses to the left of the load have the same magnitude, the members which are "enclosed" by the two loads are equally stressed and the stresses in all members to the right of the load are equal, whatever the position at which we assume the load to be. A simplification of the diagram therefore suggests itself, viz., to draw only one stress line for each case instead of laboriously repeating the same line for every member that is equally stressed. It is immaterial where we draw this line, providing it is parallel to the bridge member corresponding to it. This consideration brings us to a further simplification, viz., to draw only one line straight through the diagram and parallel to the bridge members; this line will be cut by the horizontals in proportion to the stresses which we are seeking. A single line will give us all the desired stresses in any of the diagrams, the number of members equally stressed being counted on the lattice girder itself on either side and between the two loads.

Now we come to the final stage, and simplify further by reducing all the diagrams to a single one. The reaction at the left point of support gradually decreases as the load moves from left to right; the reaction curve follows a straight line and may be plotted if any two values are known. Instead of working out the reactions for each diagram, let us then work out two extreme cases and plot the reaction curve over the span of the bridge. Where this curve intersects the perpendiculars from the panel junctions denoted by k (Fig. 4) we may scale off the reaction at the point of support when the load is on that panel junction. If we call the two loads P and Q respectively, and assume P to be over the left hand point of support of the girder, then the reaction $R_0 = Q\frac{n-1}{n} + P$. Placing P over the right hand point of support we get $R_0 = -\frac{Q}{n}$ Where $n =$ number of bridge panels. From these two formulæ we can draw the reaction curve and scale, the reactions at the left hand support for any position of the rolling load. These values, however, in themselves do not interest us any more. What we want is the line parallel to the cross members through the point k. From the intersection of this line with the horizontals denoting the constant loads we may scale off the stresses in all the members directly.

In all the diagrams the different cases corresponding to the different positions of the load are labelled I, II, III, &c.

Regarding the boom stresses we know that these increase in arithmetical progression. If the load is standing just beyond the third panel then the boom stress in the third panel will be three times the stress in the first panel. Diagram Fig 3 makes this quite plain. As in the simplified diagram we only draw the diagram for one stress line for each position of the load, we have to multiply the stresses obtained with the number of panels up to the load, that is with an index constant, which corresponds to the number of the case under consideration. For case I it is 1, for case II it is 2, and so on.

The line in the diagram which gives us the boom stress in the first panel for each separate case may be found by completing the triangle of which point k is the apex, by drawing a second line parallel to the second cross member of the girder. The points of intersection of these two crossed lines with the horizontals A, B and C represent boom stresses.

A comparison of the two types of diagram will show us that we need not consider the boom stresses represented by a_2, a'_2 and b_2, b'_2, &c., which lie above the apex k, as these will be smaller than the stresses below k. The important stresses in the boom are cc', $c_2c'_2$, $c_3c'_3$, &c. It may happen, however, that AB is large and BC is small; a case which is demonstrated in Fig. 5. Then the boom stress bb' will fall below k, and will have to be added in to the stress cc'.

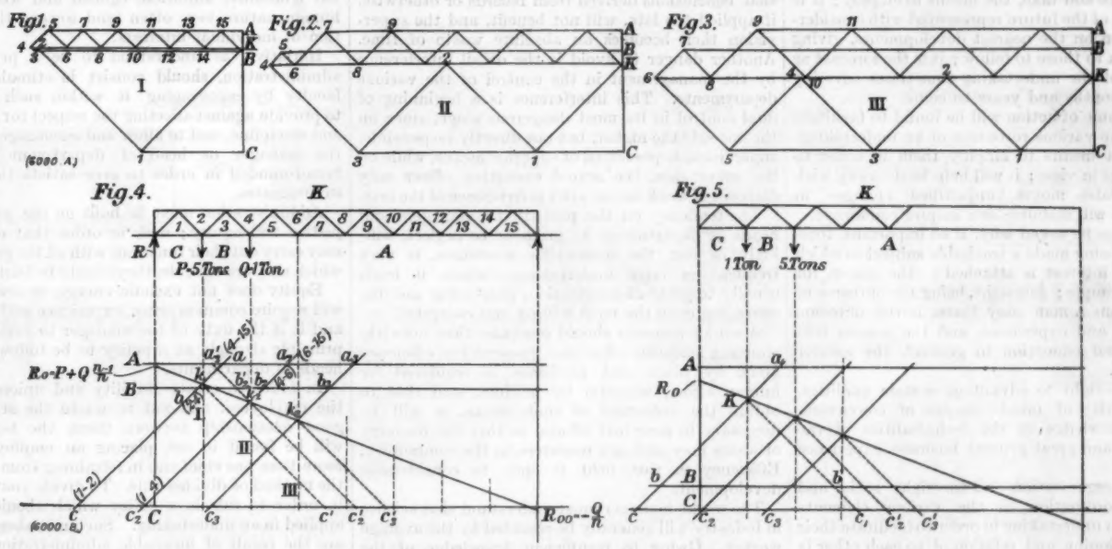
A summary of all the stresses would read as follows:—

	Case I.	II.	III.
Bracing member stresses—			
To left of load ...	$k\,c$	$k_2\,c_2$	$k_3\,c_3$
Between loads ...	$k\,b$	$k_2\,b_2$	$k_3\,b_3$
To right of load...	$k\,a$	$k_2\,a_2$	$k_3\,a_3$
Boom stresses ...	$c\,c'$	$2 \times c_2c'_2$	$3 \times c_3c'_3$

For the special case in Fig. 5—

	Case I.	II.	III.
Boom stresses are ...	$c\,c' + b\,b'$	$2 \times c_2c'_2 + b_2b'_2$	$3 \times c_3c'_3 + b_3b'_3$

More than two loads will mean more than three horizontals; the principle of the diagram holds just the same. The diagram is also valid for lattice girders of other construction, as, for instance, when every second member is vertical. The stresses in the vertical members will be scaled from k on the perpendiculars, they are in fact equal to the reaction



at the support at any position. As regards the notation, the usual practice has been adhered to of denoting the bridge members by the letters or figures which enclose them on either side and using the same letters or figures to mark the corresponding lines in the diagram. Thus k (1–2) means the two stresses k–1 and 1–2.

WORKS MANAGEMENT.

By F. C. VAN DYKE.

THE works manager in charge of a large up-to-date engineering factory must be a man of sound theoretical and practical industrial and commercial experience.

While there is a growing tendency to demand that the works manager be a college or High School-trained engineer, it is essential that he should have the same practical and varied engineering experience as is required from the self-made man, but, whether his initial training be scholastic or practical, or a combination of both, mere opportunity without fitness will not produce the successful works manager.

Modern management should proceed slowly at first, but with directness and precision, being aware that clear thinking and good organization can help a poor plant, but that bad management will be of no assistance to a good plant. Considerable thought and writing by various of the principal leaders of the world's industries have been extended to the subject of what a works manager's principles and

education should be with reference to administration in general. It is possible to summarise requirements as consisting essentially of organization, foresight, co-ordination, supervision or control, command and diplomacy. The most common of the subdivisions will consist in the proper application of the division of labour, unity of command and management, the subordination of private to general interest, initiative, equity and the stability and union of the employees. Organization as understood here should be the formation of a staff so organized socially, materially and clerically as to co-relate all the functions and their interlinkings towards the attainment of a foreseen end.

Organisation based on the centralisation of powers under one head is better than organisation based on dual control, if unity of action and thought is to be attained.

Another great essential of management is represented by foresight, which has an infinity of opportunities to manifest itself; its principal and most sensible and practical manifestations will consist in foreseeing the programme of action of an undertaking.

The programme of action must be consistent with the result in view, the line of conduct to follow, the steps to make and take, the means to employ; it is the mapping of the future represented with considerable precision on the nearest developments, giving less precision to those to follow; it is the forecast as to the run of the undertaking sometimes covering periods of months and years to come.

A programme of action will be found to facilitate the use of the various resources of an undertaking, and the best means to employ them in order to reach the end in view; it will help to do away with hesitation, false moves, unjustified changes in direction; it will stabilise and inspire confidence.

It may here be asked why, if so important, foresight is not being made a teachable subject to which the greatest interest is attached; the reason for this is very simple; foresight, being the outcome of all the lessons a man may learn, is the outcome of education and experience, and the greater this experience and education in general, the greater the foresight.

To use foresight to advantage certain qualities, such as activity of mind, courage of conviction, stability, knowledge of the technicalities of the undertaking and great general business experience are essential.

Following organisation and foresight, social and material co-ordination of the various elements involved in an undertaking in order to facilitate their proper functioning and relation of to each other is one of the principal duties of management.

A good social organisation, properly defined, goes a long way towards the requirements as understood by social co-ordination; materially it will cover such points as proportion of expenditure, capital, size of works and machine space, output, stocks, requirements, sales. In other words, it will serve to give to things and actions their proper proportions. In an undertaking well co-ordinated the following facts will be noticeable:

Each department or service will work in co-ordination with the others, the scheme will ensure the timely provision of the necessary tools and gauges, the manufacturing departments will see that the articles required are being produced in quantity and quality, the progress department will know what to urge and when, the financial side will provide the necessary capital; in other words, all spokes of the wheel will work to centralise their efforts. Such a co-ordination, no doubt, will demand intelligent, active and experienced management; and that this is often lacking is shown in the great many undertakings where each service, works as if it stood by itself, and without taking notice of its neighbours' service, or the volume of the undertaking. Such tendencies of the employees or heads of departments is full of harm to the undertaking, and is not the result of proper management, it is the outcome of no co-ordination or its insufficiency.

In any undertaking, control consists in verifying whether things develop according to the programme laid down, the orders given, and the systems and methods adopted; its aim is to single out the faults and errors in order to redress and avoid their recurrence. It applies to all things, persons and actions.

From a manager's point of view, it is necessary to make certain that the programme is applied and adhered to; that the staff organisation is complete; that the charts are made use of; and that orders are carried out systematically.

From a commercial and manufacturing point of view, the control of the raw or other materials received and used in the manufacture or assembly should be exactly appreciated in respect of quantity, quality and price, the stocktakings carefully made and the engagements kept.

From a technical point of view, control must be established over the flow of operations, the results of inspection, and the upkeep, maintenance, and working of the machines.

From a financial point of view, control will extend over books and records, resource and the financial requirements.

With regard to security, it is necessary to insure that the means adopted to protect property and employees is properly and adequately covered.

In order that control may be thorough, it should be applied in time and followed by prompt approval or decisions as the case may require, as it is evident that conclusions derived from records or otherwise, if applied too late, will not benefit, and the supervision then becomes an absolute waste of time. Another danger to avoid is the detail interference by the management in the control of the various departments. This interference is a beginning of dual control in its most dangerous stage, since on the one side the higher, but not directly responsible, supervision is possessed of superior means, while on the other side, the actual executive officer only disposes of weak means after interference of the first.

The tendency on the part of the managers and heads of departments to jump or to neglect, willingly or not, the responsible executive, is very frequent in large undertakings, where it leads usually to great dissatisfaction, paralysing and discouraging even the most willing and energetic.

A works manager should recognise that notwithstanding scientific effort and research the efficiency given by plant and machines is regulated by human effort, wasteful by instinct, and that to obtain the reduction of such waste, it will be necessary to save lost efforts, so that the recovery of waste may add new resources to the community. Efficiency in this field is open to considerable development.

The works manager must understand that science in industry will generally be resented by the average worker. Owing to insufficient knowledge of the economics ruling industry, he believes that the extra profit thereby derived passes to the employer without relative advantage to the worker, and that efficiency of employees penalises others by unemployment. It will, therefore, be the manager's duty to see that scientific improvements shall be introduced with foresight and tact.

One of the most common subdivisions of administration a manager should be well acquainted with is that relating to the division of labour, which should aim at increased and better quality of production with equal or less effort. The head of a department always going over the same transactions will, just as the worker always doing the same operations, become more efficient, increase quality and attain superior output with less effort, than would the head of a department or worker producing a great variety of articles. The division of labour allows the number of items otherwise demanding attention, to be considerably reduced, and it must be recognised as the best means of employing individuals collectively.

This does not only apply to technical duties, but to all work without distinction, and especially in works with a large number of workers and conducting various operations, demanding capacity and skill.

Division of labour resulting in the specialisation of functions and the separation of powers, are advantages universally admitted, but one must not forget that the division has its limits which experience should enable a manager to define.

A principle of administration of great importance centres in the fact that an employee or head of department must not receive instructions from more than one chief, if this principle be not applied vigorously authority is upset, and efficiency of control will be lost.

As soon as two persons claim authority over an employee or a department, a certain ill-feeling is bound to set up; difficulties will increase and troubles will appear, such as complaints and discussions, tending towards the elimination of the dual control or the downfall or discouragement of one of the two chiefs, usually of the less persevering but not necessarily the less valuable.

Dual control is a principle which proper organisation and experienced management will never create or allow to exist; dual control has been full of harm to a great many undertakings, although it sometimes establishes itself for reasons most judiciously explained and apparently correct, such as to strengthen a management, a department or a division, or to complete it by additional knowledge.

Another principle of administration to which the works manager should devote considerable attention is the subordination of private interests to the interest of the community. This principle means that in an undertaking the interest of an employee or a group of employees must not prevail against the interest of the undertaking as a whole. At first it appears that such a principle should be self-evident, but ignorance, ambition, egoism and weakness of human nature very often tend toward the protection of individual interests.

Initiative, as understood to be a principle of administration, should consist in stimulating this faculty by encouraging it within such limits as to provide against affecting the respect for authority and discipline, and to allow and encourage initiative the manager or head of department must be broad-minded in order to give satisfaction to his subordinates.

Administration must be built on the principle of justice and equity; and, in order that employees may carry out their functions with all the good will of which they are capable, they should be fairly treated.

Equity does not exclude energy, or severity, but will require common sense, experience and kindness, and it is the duty of the manager to establish this principle strongly as a policy to be followed by all heads of departments.

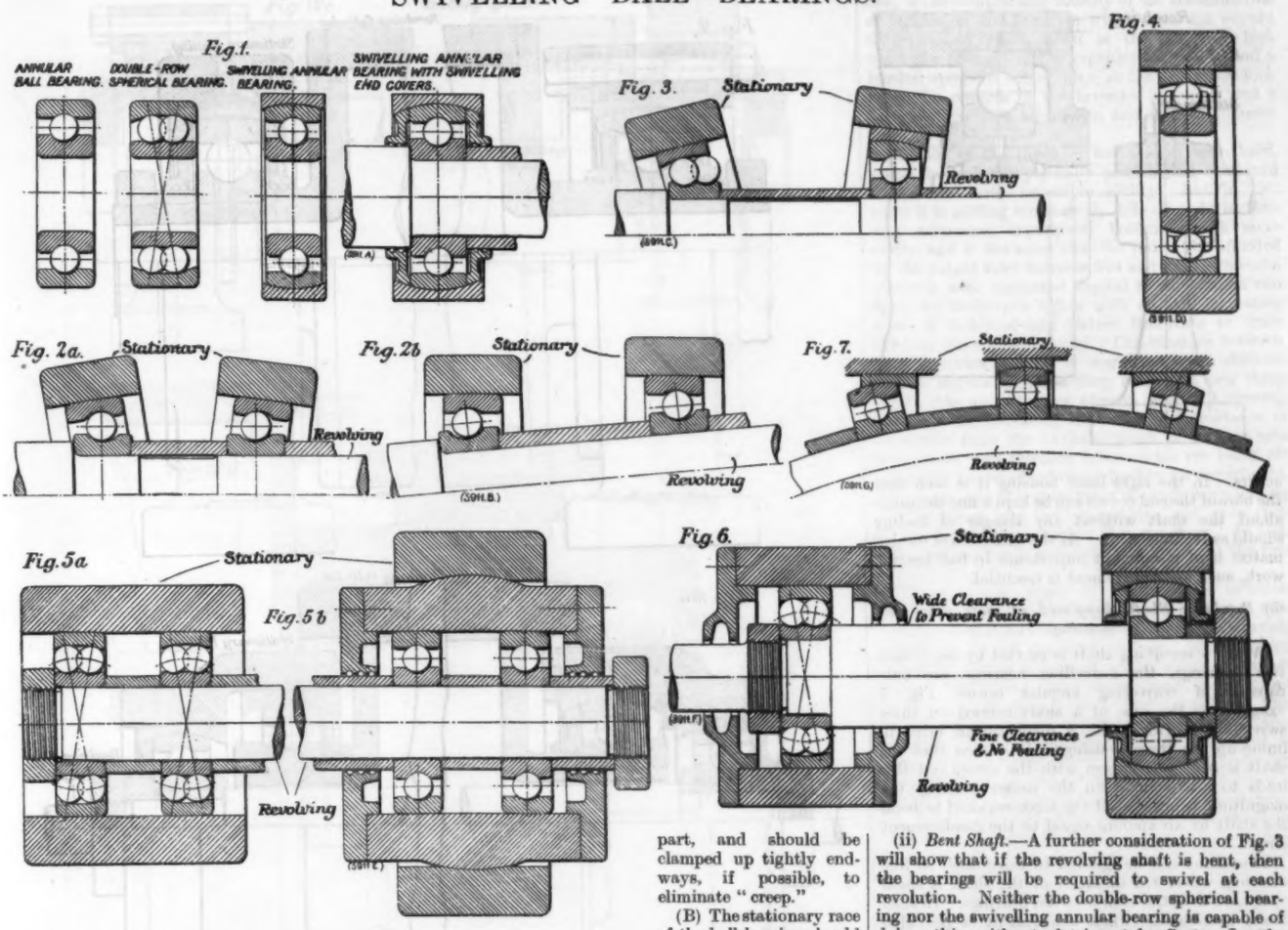
In order to create stability and union between the employees, and not to waste the strength of good relationship between them, the best means will be found in not placing an employee under more than one chief and in refraining from applying the method of divided rule. To divide your enemies in order to rule is a policy which should not be applied in an undertaking. Such mistakes in policy are the result of incapable administration, incomplete comprehension of affairs, or preference to private against common interest, and it is to be strongly condemned as it is most harmful to any undertaking.

There is art and diplomacy in the creation of stability and union of the employees in a large undertaking, and it is the duty of proper management to secure this.

While both engineering and administration knowledge have always been the chief essentials in factory management, it is yet far from being sufficiently recognised by the average engineer that the administrative capacity is becoming a prime asset in the larger undertakings. Sufficient strength cannot, therefore, be laid on the fact that lessons on administrative principles should from day to day form a greater part of the training and education of our new generation of engineers.

DIESEL ENGINE USERS' ASSOCIATION.—At the December meeting of the Diesel Engine Users' Association, Mr. Charles Gould, A.M.I.E.E., electrical engineer to the First Garden City, Limited, Letchworth, was elected president for the ensuing year, and Mr. Percy Still, M.I.E.E., M.I.Pet.Tech., chief engineer and manager to the Chelsea Electricity Supply Company, Limited, was re-elected honorary secretary. Messrs. Geoffrey Porter, A.M.I.C.E., and A. W. A. Chivers, were elected members of the General Committee in place of the two members who retire at the end of their term of office. The present members of the Standing Committee on Insurance, which deals with any question arising in connection with the standard policy of insurance against breakdown at Lloyd's, which has been approved and adopted by the association, were all re-elected for a further term of office. Particulars concerning the Association can be obtained on application to the Honorary Secretary, 19, Cadogan Gardens, London, S.W.3

SWIVELLING BALL BEARINGS.



THE PRINCIPLES AND PRACTICE OF SWIVELLING BALL BEARINGS.

By W. E. BAKER, M.C., B.Eng.

IN some classes of machinery it is not possible to obtain the degree of accuracy in aligning the bearing housings which is requisite to permit of the use of ordinary annular single-row ball bearings. This leads to the adoption of swivelling ball bearings, and the following investigation is intended to assist users of ball bearings to estimate the necessity for, and utility of, swivelling ball bearings, and to arrive at a suitable design of mounting to meet the requirements of any particular case.

It should be stated that in many classes of good machine work swivelling bearings are not necessary; housings can be bored out at one setting or can be registered together so as to ensure correct alignment. Thus, in machine tools, automobiles, electrical machines, fans, pumps, &c., there is only occasional need for swivelling bearings. When it is remembered that in the annular type, a swivelling bearing is more expensive (on account of the spherical seating) and in the spherical type a lower load-bearing capacity results (on account of the increased radius of the ball track in the outer race) the advantage of using rigid bearings as far as possible will be recognised.

Swivelling bearings should therefore only be used where housings cannot be correctly aligned, as in built-up machines found in the textile, paper-making, and other trades, and in cranes, trucks, &c.

In order that the following notes may be appreciated, the elementary principles of mounting bearings are given here:—

(A) The revolving race of a ball journal bearing must be made a tight fit to the revolving part, and should be clamped up tightly endways, if possible, to eliminate "creep."

(B) The stationary race of the ball bearing should be made a push fit on, or in, the stationary part and left free endways. This will ensure it taking up its correct position opposite the revolving race. There is no tendency for the stationary race to creep unless the revolving part is out of balance.

(C) Ball thrust bearings must be mounted with the races concentric with, and square to, the axis of rotation.

(D) All ball bearings must be kept scrupulously free from dust, moisture and other foreign matter.

The types of ball journal bearings referred to are shown in Fig. 1, with the names that will be used. With regard to the swivelling annular bearing provided with end covers, the special advantages of this will be made clear in the following:—

1. JOURNAL BEARINGS.

(*a*) *Revolving Shaft Supported by Not More than Two Housings.*

(i) *General Considerations.*—Fig. 2A indicates the stressing of the balls of ordinary annular bearings when the housings in which they are mounted are not parallel. Such a condition will quickly cause the destruction of the bearing.

Fig. 2B shows how a similar action occurs when the housings are parallel, but suffer from a displacement error in alignment.

Fig. 3 shows how either a double-row spherical bearing or an annular swivelling bearing will completely correct an angular error in the housings which support a revolving shaft. In both cases the bearings swing over until a correct alignment is obtained, and then continue to run in this position. It is easily seen that the displacement error referred to in Fig. 2B would be similarly corrected, if the shaft is supported in only two housings.

(ii) *Bent Shaft.*—A further consideration of Fig. 3 will show that if the revolving shaft is bent, then the bearings will be required to swivel at each revolution. Neither the double-row spherical bearing nor the swivelling annular bearing is capable of doing this without detrimental effects. In the former type, sliding friction will occur between the balls and the inner race. In the latter type, sliding friction will occur on the spherical seating. Under these circumstances neither type of bearing can continue to function satisfactorily for any length of time.

Fig. 4 shows the type of bearing which would be necessary to allow pure rolling motion when the bearing swivels. It will be seen that both races are ground spherical. This bearing, although possessing the above advantage, gains it at a great expense of load-bearing capacity. The contact between the balls and the inner race is that of two convex surfaces, of which the load-bearing capacity is but a fraction of that possessed by a ball in contact with a concave race groove of properly designed proportions.

(iii) *Two Bearings per Housing.*—In paragraph 1 (*a*) (i), the case was considered of a shaft carried on two independent housings. Fig. 5A shows two spherical bearings in one housing. As the bearings are capable only of swivelling about different centres, this mounting is rigid and the shaft is not allowed to swivel. To deal with two journal bearings in one housing, the housing itself must be made to swivel, and this is done in Fig. 5B.

(iv) *Exclusion of Foreign Matter.*—To ensure that the bearings in Fig. 5B are kept dust-proof it will be noticed that the end covers have been fixed to the swivelling part of the housing and not to the rigid part. This makes the mounting comparable to the swivelling annular bearing with end covers shown in Fig. 1. Fig. 6 illustrates this point further. In the left-hand housing it will be noticed that the bore of the end covers has had to be made much larger than the shaft diameter in order to prevent fouling when any swivelling

SWIVELLING BALL BEARINGS.

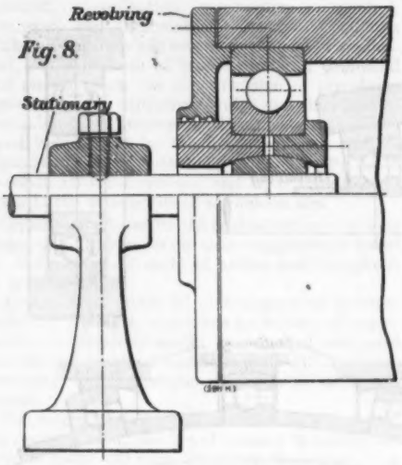


Fig. 8.

occurs. In the right-hand housing it is seen that the bore of the end covers can be kept a fine clearance about the shaft without any danger of fouling should swivelling occur. As the exclusion of foreign matter is of paramount importance in ball-bearing work, such an arrangement is essential.

(b) Revolving Shaft Supported in more than Two Housings.

Where a revolving shaft is carried by more than two housings, the swivelling bearings are only capable of correcting angular errors. Fig. 7 exaggerates the case of a shaft carried on three swivelling bearings with a displacement error in lining-up the three housings. It is seen that the shaft is bent to conform with the error, and this leads to an overload on the centre bearing, the magnitude being that of the force required to bend the shaft by an amount equal to the displacement error.

This point can be ignored in cases such as line shafting, where the diameter of the shaft is small compared with the span between bearings. In such cases, particularly where adjustment is provided (as in all line shaft bearings) very little overloading of the bearings will result from the small uncorrected displacement error.

(c) Revolving Outer Member and Stationary Shaft.

In this case it is not permissible to use the swivelling annular type of bearing, as by the principle (A) given in the opening remarks, creep would take place between the spherical surfaces. Fig. 8 shows a type of bearing which could be used to deal with this case in exactly the same manner as the swivelling annular bearing deals with the case given in 1 (a) (i). The spherical swivelling surface is arranged on the stationary member, and will completely correct angular and displacement errors between the stationary spindles when not more than two independent spindles support the revolving member. In practice the same results would usually be achieved as shown in Fig. 9. In this case a spigot is brought down from the revolving cylinder to carry the inner race of an ordinary swivelling annular bearing with end covers. The outer ring of this bearing is then mounted in a stationary housing and the bearing will correct angular and displacement errors between the two stationary housings.

(d) Revolving Outer Member and Revolving Shaft.

Four possible solutions to this question are given, with the reservations made in 1 (a) (i) and 1 (c), that is to say, that both revolving members must be accurate at the points at which the bearings are applied. The mountings shown will correct angular and displacement errors between the stationary housings in which the bearings are carried, where not more than two stationary housings are required to carry the revolving parts. If more than two housings are used only angular errors will be corrected.

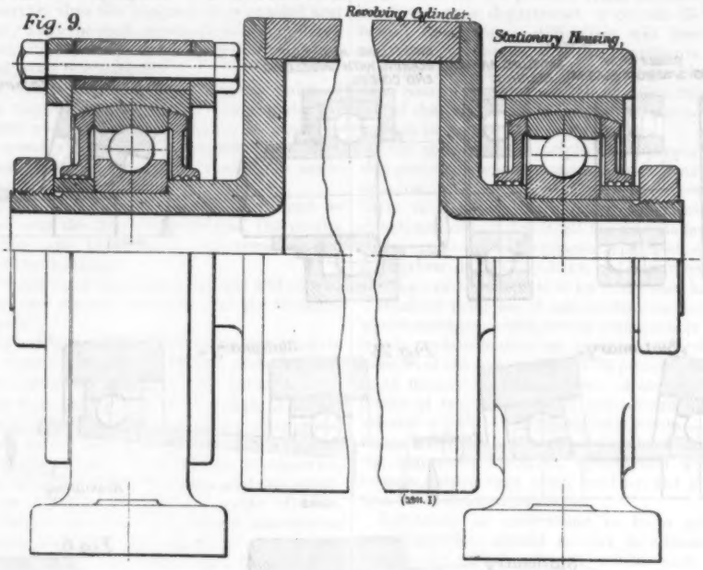


Fig. 9.

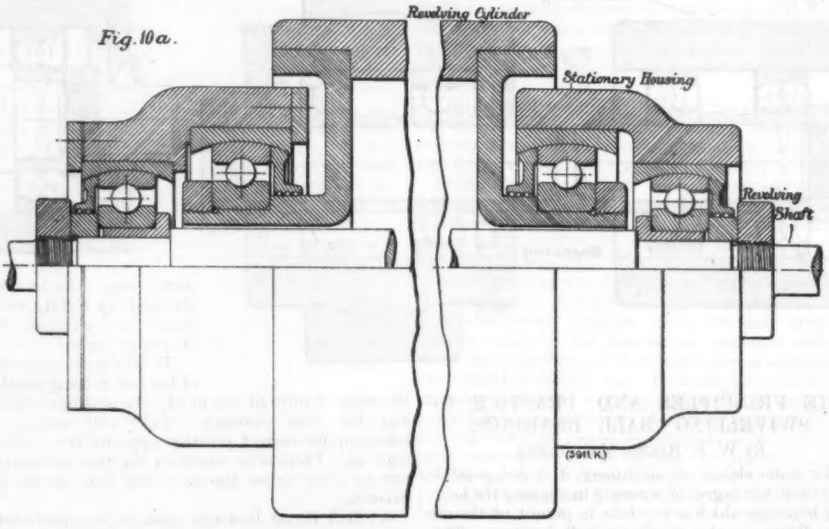


Fig. 10a.

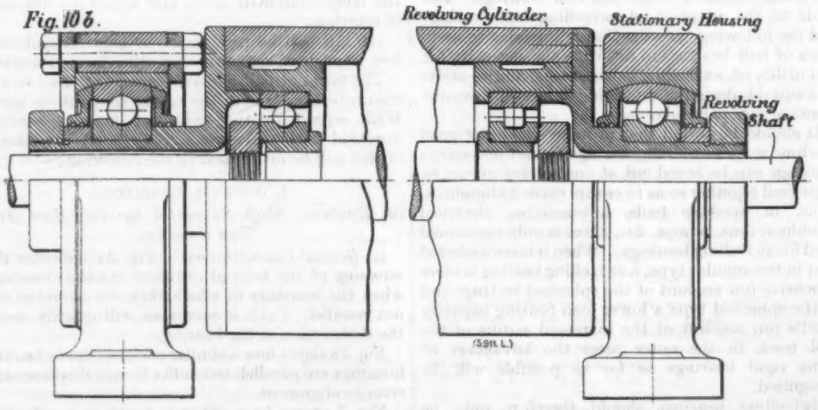
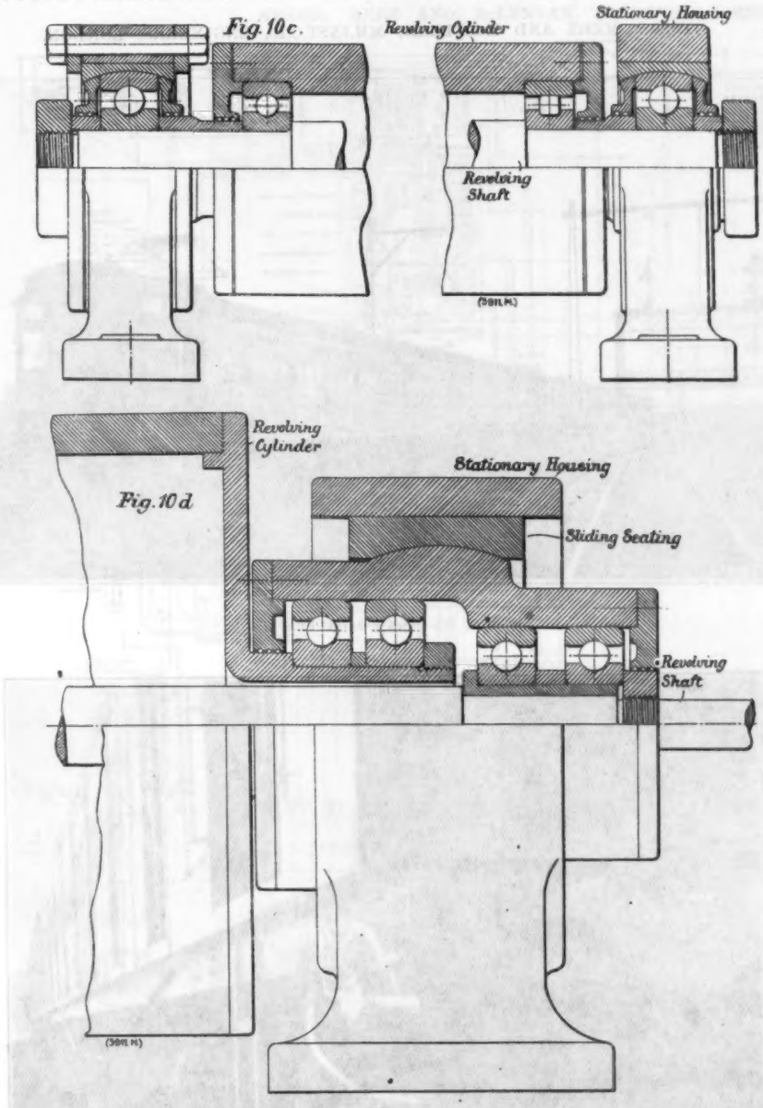


Fig. 10b.

Fig. 10A shows each revolving member carried by a swivelling bearing, the two swivelling bearings on each end being mounted in one housing. Each bearing carries the load only of that part to which it is fixed.

Fig. 10B shows one swivelling bearing used between the revolving cylinder and the stationary housing. The shaft is carried on an annular bearing mounted in the cylinder. As both races of this bearing revolve, they must be firmly fixed to the cylinder and shaft respectively (*c.f.*, elementary principle (A)). In a ball journal bearing this is not possible (*c.f.*, elementary principle (B)). An annular roller bearing is therefore used in this position. The outer race is straight-bored and there is no possibility of nipping the rollers endways. Fig. 10c

SWIVELLING BALL BEARINGS.



is similar to the preceding one, except that the swivelling bearing is mounted on the shaft.

Fig. 10D shows the bearings mounted in swivelling housings. If the loads on the cylinder and shaft are not in the same plane, then extra loads will be called into play to maintain equilibrium. Two bearings are mounted at each end of both cylinder and shaft to give stability.

(To be continued.)

THE CAPITALIST AND THE INVENTOR.

ONE of the strongest arguments used by Socialists is to point to the misdirection and waste of national material resources which goes on under private enterprise. One of the strongest arguments used by their opponents is to maintain that a misdirection and waste of national human resources would take place under any social system which failed to put a heavy premium upon individual initiative. Both inventive and organising talent are rare, but upon the measure of their exertion depends very largely the measure of national prosperity. Both these qualities show a very important and fundamental difference from other gifts of skill with brain or hand. It is possible, namely, to find by experiment an optimum number of hours of labour for ordinary skilled work at which on the average the highest output is obtained; some 7 hours or 8 hours daily. Beyond this, the increase in output due to longer labour is more than balanced by a decreased rate of work due to fatigue. Now inventive and organising talent is subject to no such law. On the contrary, as a recent writer put it, its best work is overwork. It is to the overstimulated brain of the man urging himself on with whip and spur, that the flashes of insight into new possibilities come, and bring with them a sustained faith in his own powers and a scorn of fatigue in putting them into execution.

Some men are born to worry and harrass and rack themselves without any adequate reason. Most of these, however, are neurasthenic natures without staying power or drive. There are many others with inventive ability who, even under the strongest inducement, only display occasional flashes of activity. But normally, the strength of the inducement is decisive. The inventors and organisers of British industry were brought to light and to high-pressure activity by the patent laws and the laws encouraging commercial enterprise and securing its fruits to the enterprising. Hardly anyone would seriously dispute this. Practically all the men engaged in running our industries would go further, and say that if the patent laws and the laws protecting private property were repealed, inventive and organising talent would cease to be manifest in anything like the same degree as at present. At the same time, however, they themselves are unfortunately pursuing a policy which negatives the effect of the patent laws in encouraging invention, while complaining bitterly of the accumulation of legislation and taxation which limit the reward of organising effort. Just as the Socialists look upon the rewards of the organiser as undue and a burden upon the community, so the organisers look upon the rewards of the inventor as undue and a burden upon their businesses, and seek to diminish them.

The lot of the inventor has always been hard, unless he was exceptionally placed, and combined commercial with inventive ability. But in two ways it is getting increasingly difficult. As technology advances, experiment becomes much more costly, and at the same time the protection afforded by the patent laws becomes less and less. Powerful interests with unlimited capital to draw upon can fight the inventor's rights with an ever-increasing mass of technical and patent literature to draw upon on disproof of novelty. Combination between manufacturers renders it more and more difficult to find anyone who is willing to back a new thing which fills an old want already filled by existing devices. Nevertheless, the essential importance of invention from the national point of view is now recognised, and research laboratories are being set up which are to afford every facility for experiment. The success of this movement depends upon getting the inventors into the laboratories, and upon their doing their best work when they are there. In fact, the problem has a psychological aspect of the first importance.

There is one more or less obvious solution. Assure to the inventor as good a reward as a man coming from outside with the same invention would obtain, and you are sure of him. The growing handicap upon individual effort would be made good. This policy, generally pursued, would result in an enormous stimulus to inventive activity. This solution does not seem likely of adoption. Men entering these laboratories are being required to sign away all rights of every kind to any invention they may make. They are to rely solely upon a reward at the discretion of the firm. A great many arguments are brought forward to defend this course, mostly of an ethical nature. It is also attacked on other grounds, with equal vigour and plausibility. Probably its real basis is as follows. The business man regards anyone to whom he pays a regular salary as an employee, and he regards the time during which the employee is working for him as his own, or the firm's. It seems to him altogether inadmissible that the employee should retain any absolute rights of property over work done in that time. In any case, he feels that the employee inventor has risked nothing of his own in working out the invention, as an outside inventor has done. Finally, he is possibly in many cases relying upon the increasing difficulties which beset independent inventors to drive them into his fold upon terms favourable to himself.

There are men working under extreme difficulties all over the country, struggling to get money for experiment and patent fees. There are others of equal ability but more sense, who see that the game is not worth the candle, and that there are surer roads to fortune. The terms offered may bring in a few of the disheartened, but they will be seeking a haven. The rest will struggle on as before, or turn to other things. The independence of intellect essential as an attribute of the inventor is usually coupled with an independence of character which leads to his feeling the signing away of his rights to be a confession of weakness. The research laboratories, on the other hand, will easily fill their vacancies with university graduates; men with most respectable records of "original" papers and laborious tests; but those who feel the least spark of original genius will not readily forego their freedom.

Apart from the genius, however, any young man of ability considers his prospects. In management, he has both patent freedom and the prospect of lucrative and commanding positions. On the other hand, the man entering a research laboratory has no promotion in the ordinary sense to look forward

to and work for. Not all men with a taste for invention and experiment are erratic geniuses unfitted for big managerial positions; but the latter require to be filled by men who have graduated by experience in management, and the research worker renounces this training, and with it the prizes. All he has in exchange is a vague promise of reward at his employer's discretion.

¶One solution of the problem is, perhaps, worthy of detailed consideration, namely, that a research laboratory should be an independent organisation, financed by the parent firm, but receiving royalties on a liberal scale to be divided among its members by agreement among themselves according to the share of each in the work done, after interest on the capital lent by the firm and other legitimate expenses incurred have been paid. One might possibly go so far as to demand the payment of all experimental expenses out of royalties, though the usual patent agreement with outside inventors does not as a rule go on these lines. Disputes in the research laboratory as to division might be referred to an arbitrator. It may be useless to put forward such a scheme. The British business man is already much aggrieved that he is less and less "master in his own house." But he must either realise beforehand or else find out by experience, that he will never get first-class research done by men who are regarded as mere employees and who have not full inducements to exercise their brains in carrying out the inquiries they have in hand.

THE MELBOURNE SUBURBAN RAILWAY ELECTRIFICATION.

(*Concluded from page* 10.)

THE rolling-stock for the electrified lines to a considerable extent consists of converted steam stock. Some new coaches are being built, but they conform generally with coaches previously used for the steam service. Converted stock of the compartment swing-door type, closely resembling the standard of British railways, will make up about 45 per cent. of the total. The remainder will consist of combination coaches with cross-seats, a corridor, and sliding end doors. The cars have no vestibule so that it is not possible for passengers to pass from one coach to another. A six-coach train made up of this type of stock is shown in Fig. 20 on this page. The whole of the new coaches built for the electrified service will be of this type, but this form of car is not new to the line, similar cars, which are now being converted, having been used in connection with the steam service. This apparent adoption of the end-door coach as the future standard for the electrified lines is interesting in view of the partial failure of the class for busy electrified services in this country and the many attemps which have been made to get away from it.

The new coaches are being built in the State Railway workshops at Newport. The body framing of the new cars is of teak, but Australian material has been used wherever possible. The interior is finished in Queensland maple, and the seats in the first-class cars are covered with green Australian leather. Those in the second-class have brown duck cushions. Most of the cars are partitioned into smoking and non-smoking compartments. In the case of the converted stock of the older compartment type, new underframes and bogies similar to those which are being used for the new sliding-door cars, are being fitted. Fig. 23 on page 41 shows one of the motor-bogies of the type which is being used throughout. The gauge as we said in our last article is 5 ft. 3 in. but both coaches and equipment are designed so that if necessary they can later be converted for 4 ft. 8½ in. gauge. The diameter of the driving wheels on the motor bogies is 42 in. The whole of the trains are operated on the multiple unit system, and the trains in general are made up of six cars as shown in Fig. 20. In such a train a motor car is placed at each end and a third one about the centre. A certain number of trailers are equipped with control gear for driving, but in general a make-up of train with motor cars at each end and non-equipped trailers is used. The weight of a motor coach is 47 tons and of a trailer 27 tons.

Each motor coach is equipped with four 140 h.p. 750 volt motors. The gear is arranged so that the maximum speed will be 52 m.p.h. on level and straight track. As the line pressure is 1,500 volts, the motors are connected in pairs in series. These pairs in turn are connected in series or parallel to give the various torques and running speeds which are necessary. A complete diagram of connections of a motor coach is given in Fig. 22 on page 41. As will be seen, the motor control arrangements follow usual lines with series-

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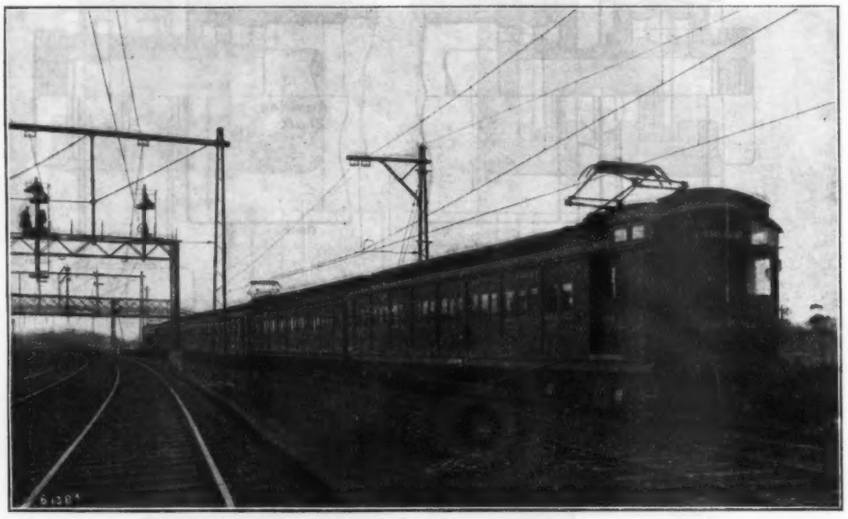

FIG. 20. SIX-COACH TRAIN.

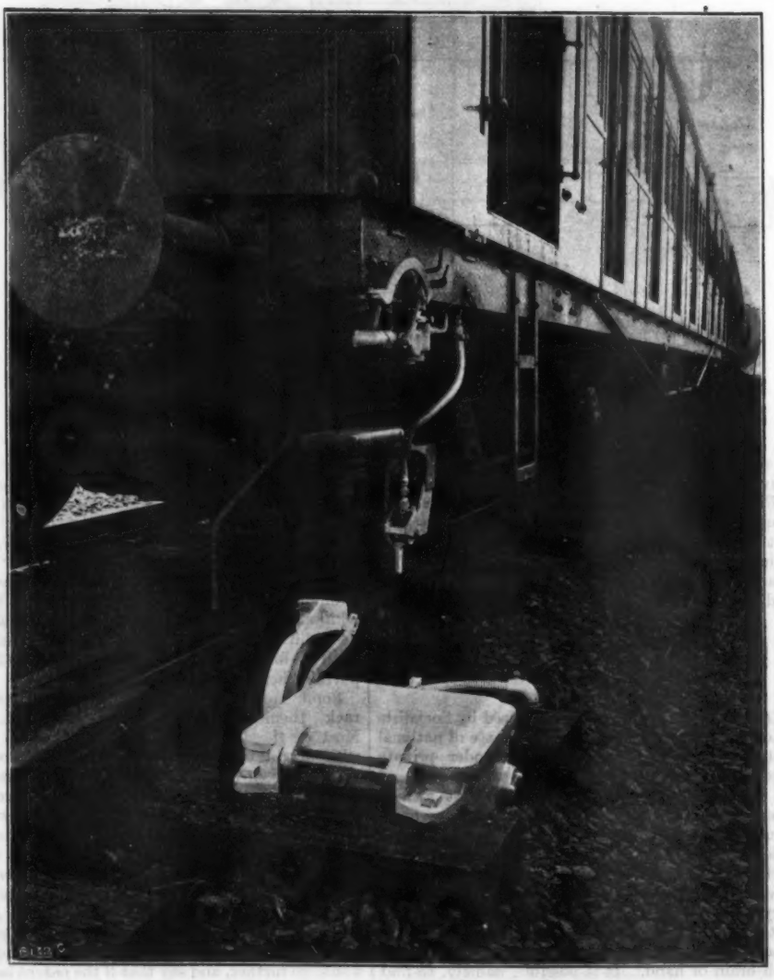

FIG. 21. AUTOMATIC TRAIN STOP.

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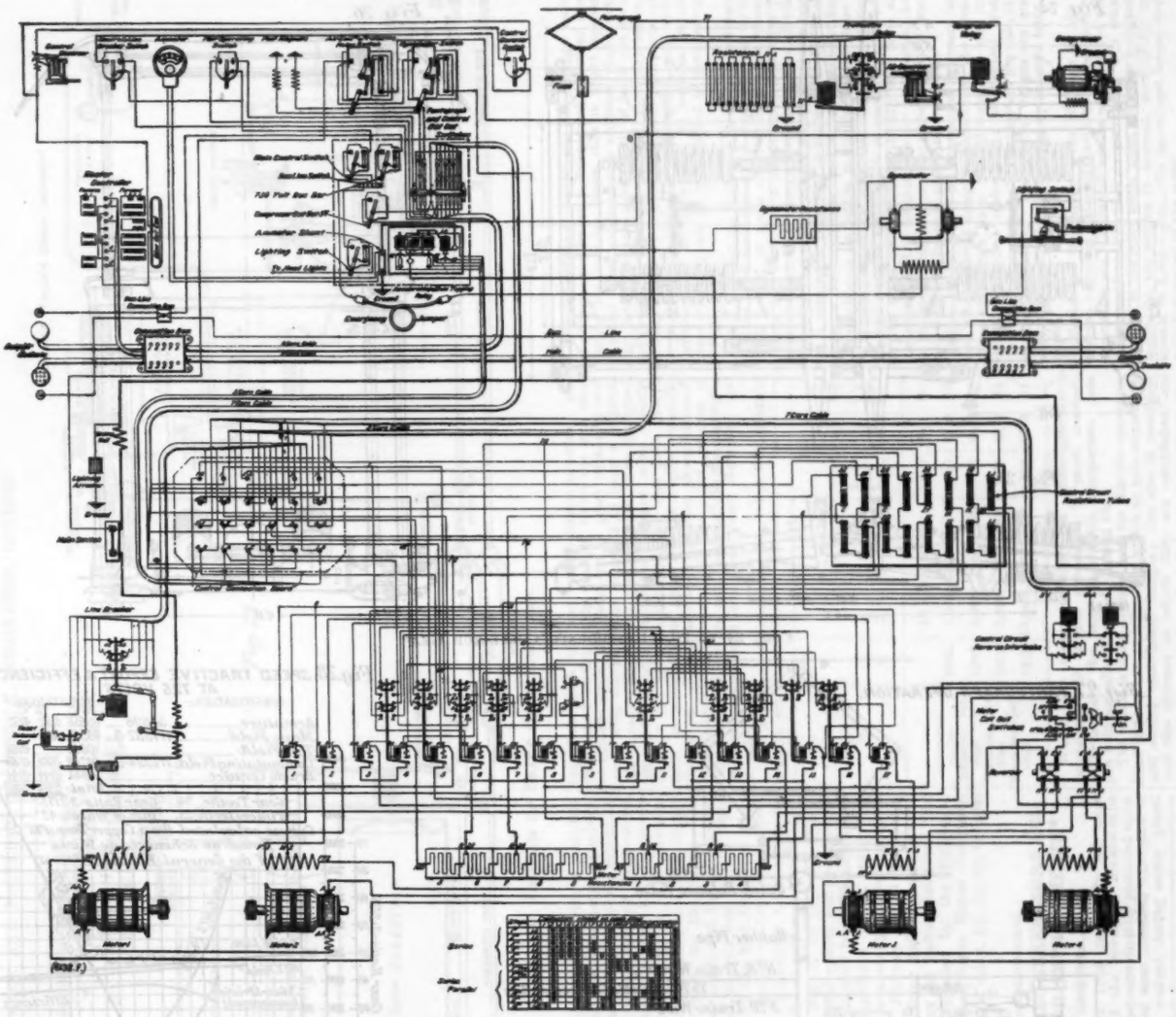

FIG. 22. MOTOR COACH WIRING DIAGRAM.

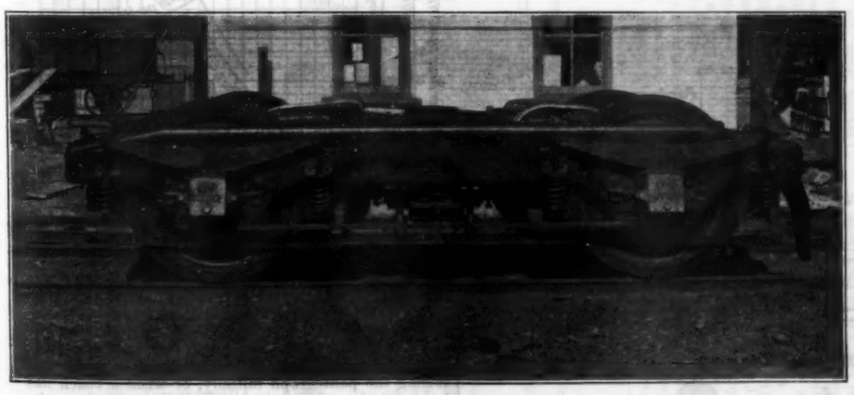

FIG. 23. MOTOR BOGIE.

contactors and resistances. The operation of the contactors is automatic and the master controller has only four positions in the forward direction and two in the reverse. The various connections can be followed through from the diagram, a series of letters and numbers being placed at either end of each connection to facilitate this. As the line voltage of 1,500 is too high to be conveniently used for the control circuits, a dynamotor is fitted. This, which is shown towards the upper right-hand corner of Fig. 22, consists of a machine with a single field and armature with two identical armature windings and commutators. Current for the control circuits is tapped off the low-tension end. The lighting circuits are taken from the same machine. The various connections to the compressor motor, pantograph operating gear, &c., will be seen from the diagram.

The arrangement of the pantograph is shown in Figs. 24 to 26 on page 42, while a diagram showing its operation and control gear is given in Fig. 27 on the same page. The pressure of the pantograph on the contact wire is so arranged that with a reasonably clean wire considerably over 500 amperes can be collected without sparking from a contact wire of 0·25 sq. in. cross section. This is the normal operating current for each motor coach. The upward pressure of the pantograph is maintained by means of helical springs the operation of which is very clearly indicated in Fig. 27. The actual arrangement will be followed from Fig. 24 to Fig. 26. The springs are carried on crossheads which are moved in and out by the operation of the pistons in the compressed air lifting cylinders. In the diagram, Fig. 27, only one lifting cylinder is shown, but the actual arrangement with two cylinders connected by a cross-pipe is clearly shown in Fig. 24. The pantograph is lifted through the spring and when in the raised position clearly always has an upward pressure imparted to it by the springs. The total working range of the current collection is between 14 ft. 6 in. and 21 ft. 6 in.

The air cylinders which operate the pantograph are

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Fig. 24

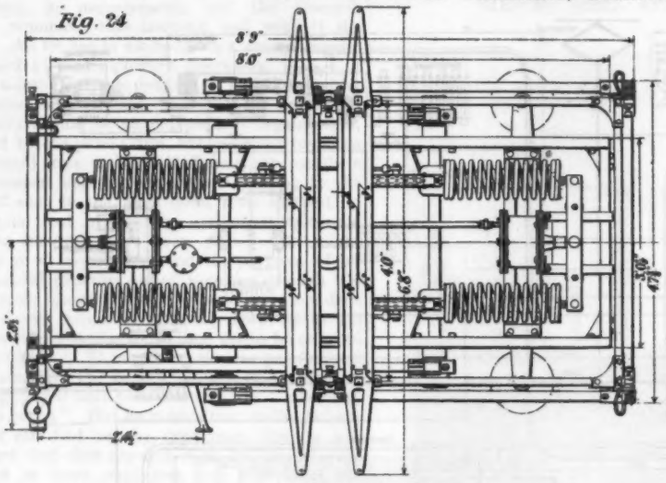


Fig. 26.

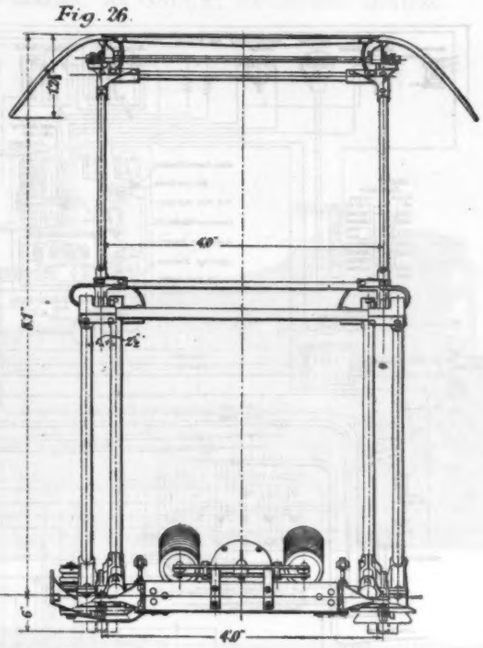
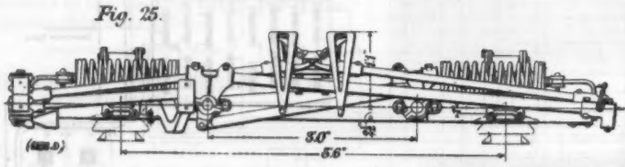
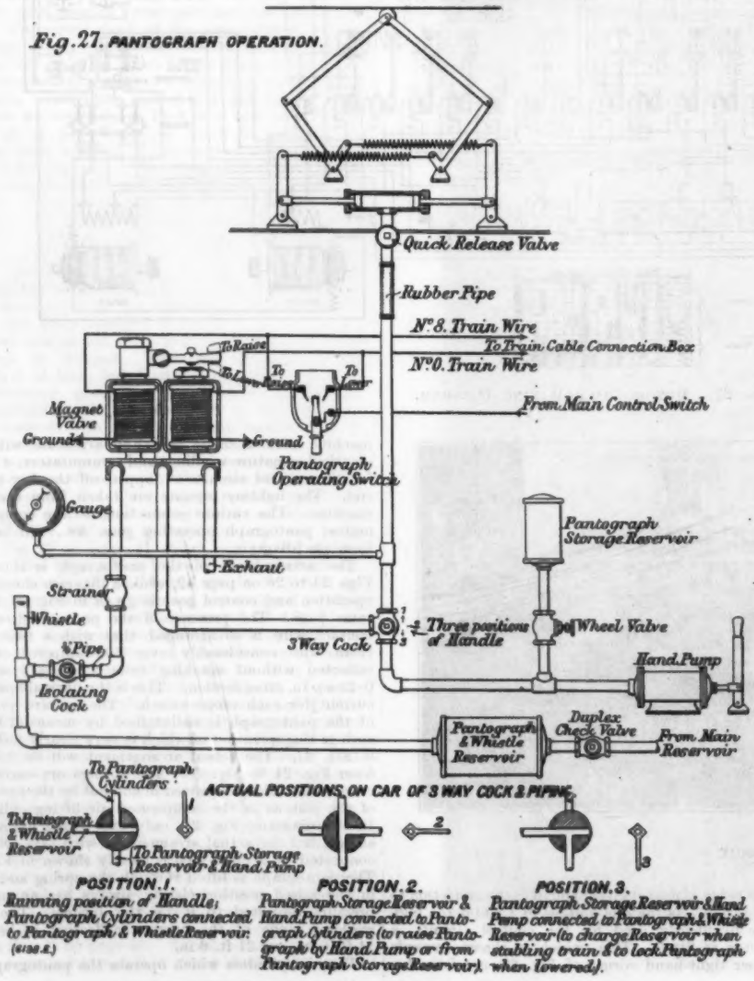


Fig. 25.



FIGS. 24 TO 26. PANTOGRAPH COLLECTOR GEAR.

Fig. 27. PANTOGRAPH OPERATION.



POSITION 1. Running position of Handle; Pantograph Cylinders connected to Pantograph & Whistle Reservoir. (6138.E.)

POSITION 2. Pantograph Storage Reservoir & Hand Pump connected to Pantograph Cylinders (to raise Pantograph by Hand Pump or from Pantograph Storage Reservoir).

POSITION 3. Pantograph Storage Reservoir & Hand Pump connected to Pantograph & Whistle Reservoir (to charge Reservoir when stabling train & to lock Pantograph when lowered).

FIG 27. DIAGRAM SHOWING PANTOGRAPH OPERATING SYSTEM.

Fig. 28. SPEED TRACTIVE EFFORT & EFFICIENCY AT 725 VOLTS.

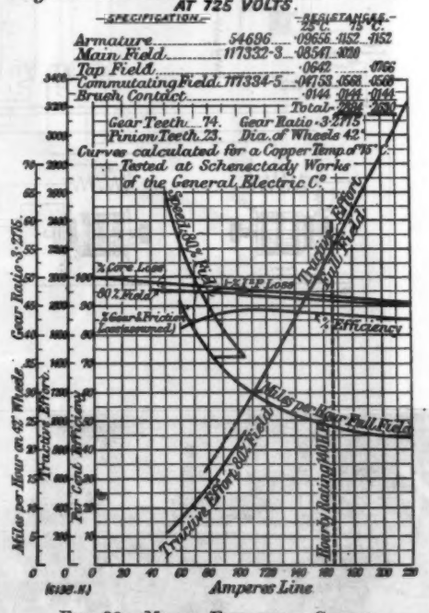

SPECIFICATION
RESISTANCE
Armature 54696 .09656 .1152 .1152
Main Field 117332-3 .08541 .1020
Tap Field .0642 .0765
Commutating Field 117334-5 .04753 .0568 .0568
Brush Contact .0144 .0141 .0141
Total .2996 .3526
Gear Teeth 74. Gear Ratio 3.2715
Pinion Teeth 23. Dia. of Wheels 42"
Curves calculated for a Copper Temp. of 75° C.
Tested at Schenectady Works of the General Electric Co
Speed
Tractive Effort
Gear Ratio 3.2715
Miles per Hour on 42" Wheels
Tractive Effort in Lbs.
% Core Loss
% I²R Loss
60 ~ Field
% Gear & Friction (estimated)
% Efficiency
Per Cent. Efficiency
Miles per Hour Full Field
Hourly Rating 600 Amps.
Amperes Line
(6139.E.)

FIG. 28. MOTOR EFFICIENCY CURVES.

supplied with air from a reservoir which in turn is supplied from the main reservoir of the air-brake system. An additional storage reservoir fed by a hand pump is also fitted. These arrangements are shown in Fig. 27, while a more general diagram showing the relation of the pantograph air system to the general air-brake system is given in Fig. 29 on page 43. In raising the pantograph initially, or when a coach has been out of service, it is necessary to use air from the reservoir which is supplied by the hand-pump. This pump is installed in the guards compartment. When the pantograph has been raised, the air compressor may, of course, be started-up and the main reservoirs charged. The control of the pantograph is carried out by means of two electro-pneumatic valves, which can be seen at the left-hand side of Fig. 27. These valves can be operated either by hand, or electrically from the operating switch shown in Fig. 27. The connections

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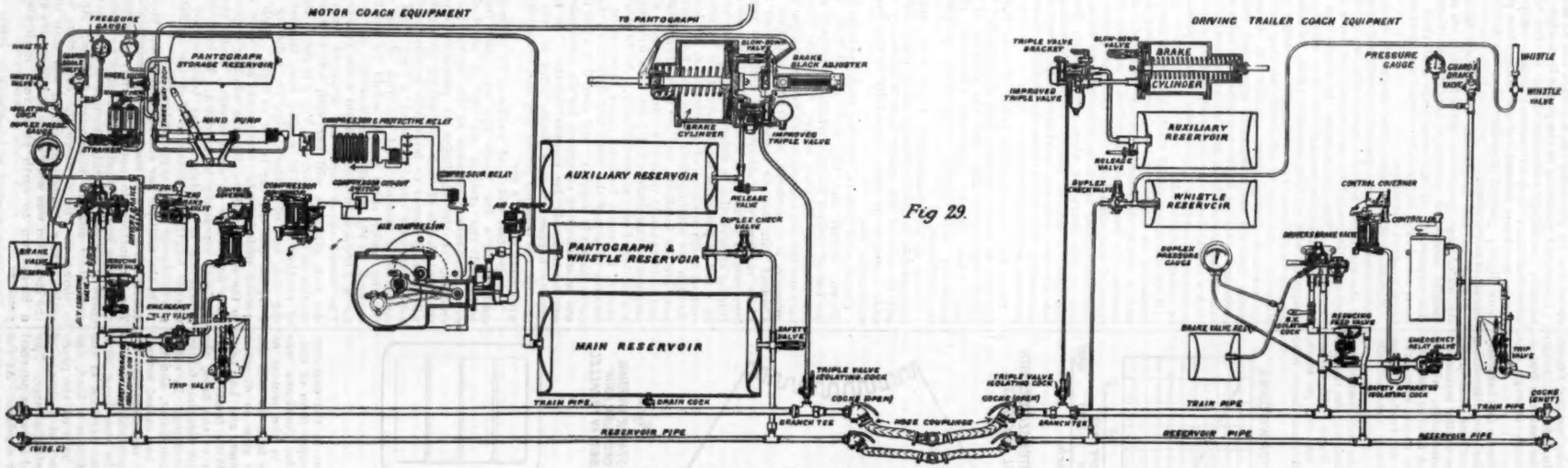


Fig 29.

FIG. 29. DIAGRAM OF BRAKE OPERATING GEAR.

of this switch to the general electrical control system of the coach can be seen in Fig. 22. These electro-pneumatic valves are intended for use during normal working and do not control connection to the hand-pump reservoir, which is used when a car is first put into service. Connection to this starting system is made by a three-way cock on the main supply to the lifting cylinders. This valve and also three cross-sections of it giving its three positions of working are shown in Fig. 27. The notes on the diagram accompanying the cross-section amply explain the connections made in the three positions of the cock, and no further reference need be made to them here.

The diagram given in Fig. 29, annexed, shows the general lay-out of the pneumatic system for operating the Westinghouse brakes, controlling the pantograph and blowing the whistle. This figure requires no considerable amount of comment as it is largely self-explanatory and the arrangement follows fairly standard lines. As will be seen it shows the connections for a motor coach and also for a trailer coach equipped with driving gear and coupled to it. The compressor is, of course, mounted on the motor coach. It is driven from the 1,500-volt pantograph circuit, as will be seen for the diagram of connections given in Fig. 22. As we have already said each motor coach is equipped with four motors giving 140 h.p. each on a one-hour rating. They were supplied by the General Electric Company of New York and represent the only considerable feature of the whole installation which was supplied from non-British sources. The complete train equipments were supplied by this company, but certain parts of the material were manufactured by the British Thomson-Houston Company, Limited, under the terms of the contract. A diagram showing the speed, tractive effort and efficiency of the motors at 725 volts is given in Fig. 28 on page 42.

The electrified lines are equipped with a complete system of track circuiting and automatic signalling. The system is an alternating current one, the signalling feed wire being energised with 2,200 volt single-phase current which is produced by 300 kw. frequency changes in the Spenser Street sub-station. The primaries of the track transformers are connected to this supply and the secondaries connect to the track. The signalling circuits are then connected through impedence bonds as mentioned in our first article. The apparatus used responds to the high-frequency alternating current and is not affected by the direct current return from the trains. Automatic train stops are installed on the ends of the sleepers opposite "stop" signals, as illustrated in Fig. 21 on page 40. These are controlled from the signal system and operated by small induction motors energised from the alternating current supply. The impedence bonds, relay and signal machines for the automatic signals were supplied by the British Power Railway Signal Company, Limited, the apparatus being built by the General Railway Signal Company as sub-contractors. The track resistances were supplied by the McKenzie, Holland and Westinghouse Power Signal Company, Limited, and the train stops, relay, &c., by the General Railway Signal Company.

FAILURES OF TURBO-GENERATORS AND SUGGESTIONS FOR IMPROVEMENTS.*

By J. SHEPHERD.

UNTIL about the year 1903 practically all large generating units were of the low-speed marine-type engine with low-speed generators directly mounted upon the shafts. These engines were excellent examples of design which had been evolved during many years' experience with mill and marine engine practice; and with sound workmanship common to all the best class of British shops, the plant was of great reliability and could with confidence be expected to have a physical life of nearly the human span of years. The low-speed generators coupled to those engines were equally massive and substantially designed, and gave practically no more trouble than did the engine flywheels themselves. The economic life of such plant, however, was immediately shortened by the rapid progress of steam turbo-generators, and nearly all the fine examples of engine generators have now been discarded and scrapped.

The relative steam consumptions, taken from running records, are of the following character:—

Type of Plant.	Year	Size.	Speed.	Steam.		Vacuum.	Steam per Kw.-Hour.
				Pressure.	Temperature.		
		kw.	r.p.m.	lb.	deg. F.	in.	lb.
Compound engine ..	1904	4,000	95	200	550	28·0	18
Impulse turbine ..	1909	5,000	750	200	550	28·5	15
Impulse turbine ..	1912	8,000	1,500	200	550	28·5	13
Impulse turbine ..	1918	20,000	1,500	200	600	29·0	11

Whilst the steam economy of turbo-generators compared with engine generators is most marked, unfortunately the same favourable comparison does not hold for reliability and physical life.

The reason is fairly obvious in so far that the necessary time has not been available in which to gain experience and evolve established designs; the size of machines and the systems in which they are established are constantly increasing, and each increase opens up new difficulties for solution and consolidation.

The difficulties of design and manufacture have been so ably set out by both British and American designers during the last few years that it might appear that a paper from an operating engineer could not fulfil any useful purpose, particularly if he is not an expert constructor. On the other hand, the operating engineer usually occupies a position of greater freedom to criticise, to represent the difficulties experienced, and, within the limitations of his knowledge, to indicate certain new ideas which appear to him helpful in overcoming such defects.

As a rule, serious failures with turbo-generators only develop when machines are of large size and form units in a system of some magnitude. Under these conditions any fault on a single unit may then be fed from the collective energy from several machines until the protecting relays of the switchgear have operated. As a result the failure of a turbo-generator is usually more or less complete, and if, as generally happens, the machine is set on fire, it may be several hours before it is cool enough for examination. By that time the charred remains are in such a condition that evidence of the cause of breakdown usually has been entirely destroyed, and it becomes a slow and painful business to diagnose with any certainty the source of weakness, and with confidence to prescribe a remedy.

After several years of experience in many stations and with different designs of machines, the more usual types of failures have been determined and may be roughly classified under: (1) Mechanical weakness, (2) Electrical weakness, (3) Heating and fire risk, (4) Ventilation difficulties. The various defects are generally very closely correlated, as will be discussed later in the paper.

Mechanical Weaknesses.—The efficiency of the steam turbine increases materially with its speed, and modern generators are now run at speeds which would not have been considered practical six years ago. The centrifugal stresses in the rotor teeth, upon the rotor coils and their insulation are serious in amount, particularly so with speeds of 3,000 r.p.m., the centrifugal forces increasing with the square of the speed.

To limit these stresses and retain the maximum

* Paper read before the Institution of Electrical Engineers, January 8, 1920.

speed of rotation, the diameter of the rotor is reduced to the smallest practical dimension, the increase in size for increasing output being more in length than in diameter. As a result, the running speed of the generator is generally above its first "critical" speed, except in the case of the double generators of the Ljungström combination, and therefore each time the plant is started and stopped, the rotor must pass through the first critical speed with its attendant risks. The cylindrical pattern of rotor with radial slots originally adopted by Messrs. Brown, Boveri and Co. has now become universal, and generally the rotor and its shaft are turned out of a single forging.

One serious result of the high speeds of rotation is the difficulty of effectively holding the rotor coils against centrifugal forces. The portion of the coils within the winding slots is retained in place by metal wedges driven into dovetailed recesses, machined out of the top of the rotor teeth. The portion of the windings forming loops at each end of the rotor cannot be held in this manner. Originally they were secured in place by steel wire bands wound tightly upon the completed coils.

An advantage of using drawn steel is that the highest quality of material can be obtained, which from the very nature of its manufacture has been thoroughly tested on the draw bench, and moreover the material is reasonable in price. Such steel bands are, however, open to grave objections. As the windings are usually cooled by air ventilation underneath them, they are arranged more or less in an open form and not clamped to an internal hub. In consequence there is a tendency for the coils to set in radially, thus slackening the steel bands upon them and throwing the rotor out of mechanical balance.

When a short circuit occurs at the ends of either the rotor or the stator, the bands are usually fused and the steel wires rapidly unwind. Again the ends of the wire banding may become unanchored.

Whenever a wire band fails, the result is invariably the wreckage of the rotor and stator windings, with more or less serious destruction of the ends of the stator core.

Consequent upon these troubles, solid rings of high-tensile steel are now used instead. These rings are turned out of substantial forgings in which internally-hidden flaws may exist, and, from the standpoint of reliable mechanical strength alone, they have not the advantage of drawn wire bands. Moreover, alloys like nickel and chrome steel are comparatively new, and the effect on them of prolonged heat and continued stress has yet to be determined. If during ageing, a slow and continuous reduction in elastic tensile strength occurs, a periodic renewal of the bands will be necessary. The failure of a band is a catastrophe to be avoided at all costs, for it generally results in serious loss of life and plant.

As an extreme example, Fig. 1 illustrates the radial stresses in pounds per inch of coil length from turn to turn of such a rotor coil, the rotor being of 36 in. diameter and 3,000 r.p.m. The stress increases in a parabolic curve from the bottom of the slot. The same curve to a different scale represents the crushing force per square inch on the insulation between the turns. Assuming that the turns are absolutely flat upon each other, giving uniform pressure throughout their area, the pressures per square inch on the example taken are :—

	Lb. per Sq. In.
Between the complete coil and wedge...	4,600
Between the last two turns	4,340
Between the first two turns	200

The choice of insulation capable of withstanding such pressures is very limited, especially as prolonged heating of the insulation and the difference between the expansion of the copper and of the wedge are also involved.

The portion of the rotor winding within the rotor slots must of necessity preserve its shape under the centrifugal forces, but the unsupported portions of the coils at the end loops have no lateral support, and there is always a risk of distortion or side slip at high speeds. The problem in certain respects is similar to that of a short strut under heavy compression, the strut being severed into many sections piled upon each other.

For many years a flexible type of coupling between the rotors of the alternator and turbine was generally used. Such flexible couplings required two bearings each for the turbine and generator. The couplings were usually of a muff form with internal teeth engaging with half couplings having external teeth secured to the rotor shaft. As the size of the combination increased, mechanical difficulties were experienced owing to the imperfect line contact on the driving faces of the teeth. Further, the coupling could with difficulty be maintained in good running balance, and it was questionable whether the connection was really of a flexible character. Some twelve years ago, Continental makers began to discard flexible couplings, and that practice has now been followed here.

The internal losses of a modern generator are about 4 per cent to 5 per cent of the rated output, and the heat resulting from these losses is almost invariably dissipated by forced air ventilation through specially-constructed air vents in the rotor and stator. In the rotor these vents are provided under the slot windings and, to find room for them, the rotor must be increased in diameter, with increasing difficulties from centrifugal forces. With higher speeds, smaller diameters, and increased length of rotors, it becomes a matter of great difficulty to pass the required amount of cooling air through the rotors. Generally there is adequate room in the stator for the air ventilating spaces at the expense of iron space. On modern machines, the volume of the stator taken up by ventilating spaces is from 15 per cent to 25 per cent of the total volume. The stator is divided longitudinally by air ducts spaced about 2 in. apart, the passages being maintained by spacing fingers attached to the steel stampings. In addition, longitudinal air passages are provided in the cast-iron frame-work behind the discs and sometimes through the stampings in addition.

This method of open construction gives a mechanically weak form of stator core and, under the alternating stress, chattering of the teeth may occur with consequent breakage. The result of the vibration on the insulation of the stator bars is obviously undesirable, without the further trouble of broken teeth. A further mechanical weakness occurs at the end of the stator where the winding must have spacings for the air freely to pass between them. The windings, although mechanically and almost continuously held in the winding slots, can only be clamped at intervals along the end connectors.

Another mechanical defect in the stator is the method of attaching the stampings to the frame. In earlier designs of generators, each stamping had two (or more) dovetailed keys on each sector, and these keys were

Fig. 1. CENTRIFUGAL STRESSES IN ROTOR WINDINGS.

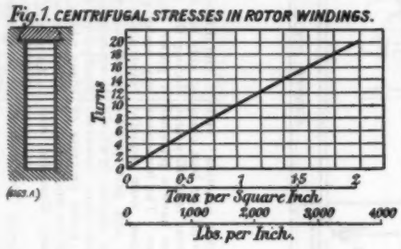


Fig. 2. STATOR SECTORS WITH EXTERNAL TEETH.

Fig. 3. STATOR SECTORS WITH INTERNAL KEYWAYS.

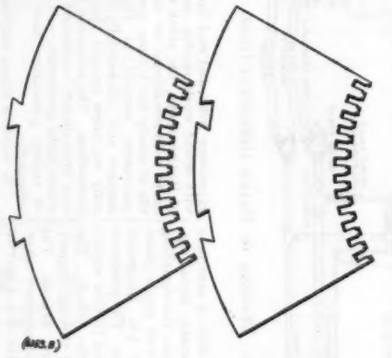
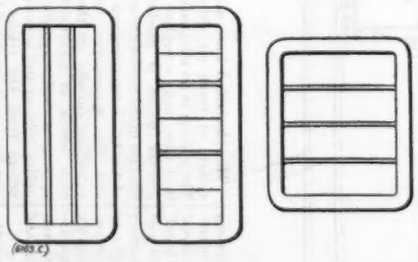


Fig. 4. STATOR WINDING, THREE-TURN BAR DIVIDED RADIALLY.

Fig. 5. STATOR WINDING, THREE-TURN BAR DIVIDED AXIALLY.

Fig. 6. STATOR WINDING, ONE-TURN, FOUR BARS IN PARALLEL.



threaded into machined keyways cut in the cast-iron frame as shown in Fig. 2. The cheaper form of construction afterwards adopted on the Continent was to stamp the dovetailed keyways in the sectors as shown in Fig. 3 with corresponding keys let into the frame. This construction does not give so direct a connection to the frame as the former, and has been the cause of numerous failures. With faulty workmanship and inadequate proportion of the keys, the core worked slack at the keyways, with complete failure of the stator after a few months' working. In other cases the volume of iron has been insufficient, and the induction in the iron near the keys has caused serious overheating of the stampings and reconstruction of the stators became necessary. The probable cause was the formation of eddy currents in the steel keys, with the overheating of the keys and the portions of the discs near them. With certain conditions of load, this overheating became so serious as to burn off the paper insulation on the discs and to throw out a shower of sparks from the burnt paper at the air discharge. The former construction having dovetailed keyways punched out of the stampings gives a sounder machine. At the same time the later method may give a good machine provided the keyways are well punched, of adequate size, and that proper allowance is made for the active metal lost by punching the keyways out of the sectors.

Inaccurate punching of the plates is another source of trouble, entailing excessive filing of the stampings after building; and to prevent serious eddy currents across the burrs caused by the filing, the plates are more lightly packed together than is desirable, and vibration takes place.

Owing to the limitation of railway facilities the stators of large generators must be built on site under usually somewhat primitive conditions. Consequently the preparation of the stampings and their building-up is not always so carefully carried out as when erection takes place in the shops.

Electrical Weaknesses.—The electrical weaknesses in turbo-alternators have generally developed since the size of the machines and the systems to which they were connected increased to over 30,000 kw. on a single set of bus-bars. The insulation on the stator bars is almost invariably micanite, worked on hot with a Haefley wrapping, and a thickness of 0·15 in. of insulation is usually sufficient for ordinary working pressures. Micanite insulation is admirable so long as it is not overstressed during short circuits. If, however, the stator bars are not adequately supported, bending will occur and cracking of the micanite insulation will result usually just inside the ends of the stator core. As a rule, such a crack cannot be detected, and its very existence is unknown until a breakdown occurs, perhaps weeks or months afterwards.

With the exception of the lack of flexibility, micanite insulation on a straight bar is in every way admirable, and is much the best kind of insulation at present known. To overcome this defect a number of different types of insulation have been introduced using Empire tape and similar fabric, interleaved with mica. Insulation of this character when new is fairly flexible and will yield a limited extent without cracking. After use at the ordinary working temperature of turbo-alternators the fabric loses its flexible character and becomes as brittle as mica.

From the constructional point of view the one bar per slot of stator winding has advantages. The bars are of reasonable size, and the number of joints is less. There is the important advantage of thinner insulation and smaller temperature gradient across the insulation.

Owing to the considerable depth of the stator slots, considerable magnetic leakage takes place across them, and division of the stator bars is necessary to reduce eddy currents in them, especially if the bars are of substantial size.

Continental makers, working under patents of Messrs. Brown, Boveri and Co. and the A.E.G., construct the bar of various laminæ, which are twisted within the slot relatively to each other. The joint between the bars and the end connectors is a matter of some difficulty; generally it is soldered, and if care and time be taken a sound joint can be made by experienced workmen. There is, however, always the difficulty that out of hundreds of joints in a machine one may be defective. During construction a defective joint may be detected by a fall of potential measurement, or by circulating a current much in excess of the maximum full-load current through the windings and feeling for hot joints. These tests are not infallible, nor are they always carried out, and unfortunately defective joints are met with. The presence of one undetected joint on a working machine is a matter of very serious anxiety. As its position is not known, it cannot be kept under observation, nor is it feasible to untape the joints and strip down the machine every time it is stopped: and even if it were, this would not be an absolute safeguard, for the same machine may run continuously for months together. In practice it usually happens that a faulty joint is only detected through the machine giving way and the solder melting, with every risk of a fire.

The greatest electrical weakness in turbo-generators constructed a few years ago was their inability to withstand the stresses set up on short-circuit. If even moderate movement of the stator bars occurs, cracking of the insulation is probable, especially if the insulation is of some age, setting up a defect which will develop sooner or later into serious trouble. If a solid conductor could be used, a very rigid bar construction is possible, and the risk of the conductor bending under short circuit would be small. As an example, in Fig. 4 is shown a three-turn per slot winding for a 5,000-kw. machine, 6,600 volts between phases. The three copper tapes are arranged lengthways in the slot, giving a stiff bar with which there was no trouble on short circuit. In Fig. 5 is shown the winding of another machine of similar size, laminated across the slot, and of better design for reducing the eddy currents, but the bar is not so rigid. Both machines worked under similar conditions, and were connected to the same bus-bars, but the winding shown in Fig. 4 gave no trouble on short circuits, whilst the winding in Fig. 5 repeatedly broke down. In later designs the lamination of conductors has been carried to much further lengths, so much so that the insulation upon the conductor really supports the bar.

On the multiple bar and crushed strand construction, difficulties occur with stator bars of considerable section. The conductors do not nest firmly together, and a tight mica wrap around them cannot be made, so that there is always a certain amount of slack between the conductors and the mica around them. An example is shown in Fig. 6 where the conductors were slack within their insulation, and in less than three years the insulation was worn away at the corners and caused a breakdown to earth at a very moderate working pressure.

The latest method of constructing stator bars is a

more complete development of lamination. The stator bars are divided radially into several copper tapes, each separately insulated, and each tape is connected to another tape in the several bars forming the winding pitch at the ends of the stator. At each joint the tapes are twisted relatively to each other, giving a complete change of position in each complete phase winding from the star point to the main terminal.

This construction eliminates eddy currents and gives a uniform distribution of current in every section of the stator bar. It has the additional advantage of small joints, which enable the tapes to be fusion welded together. The only large joints occur at the star points and at the main terminal connections, and these can be arranged well out of the revolving field. However, a bar laminated so completely has little stiffness or mechanical strength and requires very careful support.

The popular remedy against short-circuit stresses is the provision of high reactance within or without the machines, reducing the current on short circuit to from 8 to 10 times full-load current. This reactance can be built into the machine itself by providing the necessary magnetic leakage, and internal reactance gives the greatest protection to a machine. External reactance gives protection from feeder or bus-bar troubles, but not from internal short circuits. But whether the inductance be internal or external, the result on the regulation of the machine is the same, resulting in poor regulation. To overcome this, each generator must be controlled by an automatic regulator giving satisfactory pressure on ordinary loads.

In addition to the short-circuit stresses, there is mutual attraction between the adjacent end turns of the same phase, and repulsion between the adjacent end turns of different phases. The attractions and repulsions increase as the square of the alternating current, causing vibrating forces corresponding to twice the periodicity of the system.

In large generators the ordinary method of leading away the current of the stator is open to improvement. The winding is usually terminated in split connections, clamped together by small screws with slotted heads, a somewhat crude finish for a plant of considerable size. In all large systems it is more satisfactory to lead away each phase by a separate lead-covered cable, taking care that substantial joints are made between the cable and the stator windings, and that such joints are well clamped mechanically against all possible movement.

Heating and Fire Risk.—With the old type of low-speed generator the fire risk was not considerable, as the proportion of inflammable material was small. With a modern turbo-alternator the conditions are quite different; and owing to the high speed and compact design with small volume of active material, a very considerable portion of inflammable insulation is built into the machine. As a consequence of forced air ventilation the generator is totally enclosed and, when working, no part of the winding is open to inspection. A fire within the machine can originate in a variety of ways, such as defective joints, a short circuit to earth or between the stator windings, failure of insulation or the like. An arc, however started, has immediately a considerable amount of energy fed into it, until the field current is cut off and the machine isolated from the bus-bars by relay protection. If the machine and the system of which it forms a part is of considerable magnitude, the energy fed into a short circuit is enormous, and in effect is nearly as dangerous as an explosion, so that the relays may or may not be capable of operating with sufficient speed to prevent serious damage to the machine.

With high-speed turbo-alternators the stators have usually two-pole windings, consequently about 50 per cent. of the stator winding length is usually taken up by the connectors between the stator bars. These connectors are purposely spaced in an open manner to allow the cooling air to circulate, and the air is circulated at the speed of a tornado and is constantly renewed by the fans. The inflammable character of the winding may be augmented by oily vapour and dirt carried into the machine by the ventilating air and deposited as sticky material on the conductors.

There is comparatively little fire risk with the windings which are enclosed within the winding slots, as the cooling effect of the surrounding iron is considerable. But a fire once started at or near the end connectors is immediately swept round the openly spaced windings, and their destruction is a matter of only a few seconds. To make matters worse, the momentum of the rotors causes continual rotation for from 30 minutes to upwards of an hour after the steam has been shut off, depending on the speed and size of the machine.

If air dampers are provided in the external ventilating air ducts, it is doubtful whether they could be closed sufficiently quickly to cut off the air supply and save the machine, or if there would not be sufficient air leaking past the dampers to continue the conflagration sufficient to wreck the machine even when the dampers are closed. The first intimation of anything being wrong is usually the presence of smoke and sparks at the air discharge of the machine, and every second elapsing afterwards is of vital importance.

The same objections also apply to other devices proposed for preventing the spread of the fire by flooding the interior of the machine with nitrogen, carbon dioxide, carbon tetrachloride, &c.

Even although the insulation of the machine be not actually consumed, it is usually left in so charred and brittle a condition that a re-wind becomes desirable.

Ventilation Troubles.—The amount of air required to carry away the internal heat is dependent upon the internal losses and upon the permissible temperature rise. Allowing a rise of 50 deg. F., in the cooling air, and a loss of 4 per cent. in the generator, about 4 cub. ft. of air per minute per kilowatt of output is sufficient, and this allows for a certain amount of the air being short-circuited within the machine. Even under the cleanest conditions, the air has sufficient dust suspended to choke up the internal ventilating spaces in time, and filtration of the air becomes necessary in some form or other. Further, even in our temperate climate it is desirable on the hottest days of summer to cool the incoming air. Dry air filters were originally introduced for removing the dust, and are still largely used on the Continent and in America. The filtering cloth is of considerable area, its renewal is troublesome and is often postponed until the pores of cloth become filled with dust, and the full allowance of air is not admitted.

Air washers of the spray type have been used to a considerable extent in this country, but in several cases they have not justified the high opinion in which they were formerly held, and more or less free moisture has been introduced into the machines by their use. Except in very exceptional conditions some form of filtering and cooling air is necessary. The amount of dust caught by a dry filter from an air blast of 40,000 cub. ft. of air per minute has been found per week of continuous working to be 5 lb. in the centre of London and 2 lb. at the outskirts of London.

Unless this dust be removed, it is sufficient to choke up the narrow air passages in the rotor and stator, which passages can be cleaned only with considerable difficulty, even when the rotor is removed.

The air is generally drawn into the bottom of the machine by fans attached to the ends of the rotor. In large high-speed machines the fans may be external to the machine and separately motor driven, giving control of the amount of air circulated. Whichever method of producing the draught is used, the correct distribution of the air after entering the machine is a matter of difficulty, and one can only hope that each portion of the machine received its correct proportion of air, for the running staff have no control of the air distribution, nor of the amount of heat carried off by each separate air stream. Even should the various air currents be correctly distributed when the machine is new, deposits of dirt after use will soon alter the air distribution, and the effect of incorrect distribution of air is of serious practical importance.

Practically all machines are rated on ultimate temperatures, which implies the temperature of the hottest part of the machine on the outside of the insulation; and as a matter of fact the position of this hot part is inaccessible when working, and the temperature may or may not be revealed by thermo-couples or resistance thermometers. The temperature of the ventilation air leaving the machine indicates roughly the amount of heating of the machine, but gives neither the maximum nor the average temperature, as the temperature gradient is unknown. If the separate discharge temperatures of each air current were known, a better indication would then be obtained of the hottest part of the machine.

Suggested Lines of Improvement.

The operating engineer or user of a plant as a rule can only indicate the various features which have given him trouble, and he can suggest the parts which to him appear to require improvement. The modification of machine necessary to embrace these suggestions in practice is for the expert designer to shape. It may of course, be practically impossible to adopt some of these suggestions, no matter how desirable they may be. However, the logical path along which improvement should lead is towards the ideal, halting as the practical limitations of present construction retard progress for the time being, and of course difficulties of present methods of construction are but the limitations of to-day.

So far, the paper has given a plain statement of the ordinary difficulties experienced with turbo-generators. The engineer is at a serious disadvantage when using such machines, for the requirements of his load compel all the plant to be worked at its maximum capacity, as spare plant during the past few years has generally been non-existent.

Such generating plant is entirely enclosed, and can neither be inspected nor its temperature easily determined under working conditions. There is also a probability that if a breakdown occurs it will result in a fire, necessitating rewinding and the shut-down of a large unit for 8 or 10 weeks. Faults which are suspected are difficult to locate, and, when located, nothing short of a complete re-wind is usually of service. In fact, high-speed generating plant may offer more difficulties than almost any other kind of plant. At the same time, when the plant is quite sound it requires less attention than practically any other.

From the operating point of view, the requirements of modern turbo-generators are (1) reliability, (2) efficiency, (3) ease of operation. Reliability calls for machines which shall be fireproof, the coils of which cannot break down or overheat, the insulation of which shall not fray, crack or deteriorate, and the electrical joints of the machine shall be so constructed that there is no chance of their giving way under load. Most operating engineers would consider reliability the most important of the above conditions, and would be willing to obtain it at the sacrifice of some electrical efficiency.

Ease of operation requires some better means of knowing what is happening inside the enclosed frame of the machine. It ought to be possible to determine continuously, with some accuracy and by simple means, what is the temperature of any part of the machine, and it is desirable to anticipate breakdowns by the indication of rising temperature of the faulty part, or otherwise, before the fault develops.

The output of the machine should be independent of air temperatures and if possible there should be some reserve of capacity to meet sudden overloads. With a view to considering how these conditions may be met, the several causes of failures already mentioned will be considered, and the remedy for each type of failure will be briefly discussed.

Rotor Coils' Centrifugal Force.—The difficulties of centrifugal stress resulting in the crushing of insulation between the turns of the rotor windings and the distortion of deep narrow coils, have already been indicated, and the difficulty of securing the end loops has also been mentioned. The first remedy is to manufacture a suitable insulation, and is beyond the scope of this paper. When it is realised that a pressure of over 2 tons per square inch may be encountered with the insulation between and around the outer turns, and that the insulation must stand continuously a temperature of 200 deg. F. it will be seen that the problem is not one of easy solution. The choice of suitable insulation at present is restricted to mica and various forms of hard paper. The coil should be made of as great a width as possible, and the separate turns laid flat upon each other. The support of the coils against distortion at the end of the loops can be prevented by substantial metal packing between the loops.

The safest band over the coils would be one of drawn steel tape, which would require centering by other means than the coils themselves. This form of banding is the one used for the much more severe conditions required by the reinforcement of high-velocity gun tubes.

A flexible wire or tape band has other advantages over a solid ring; the distribution of centrifugal stress is not uniform either axially or circumferentially, and this unequal loading sets up secondary stresses, in solid bands. With a laminated tape band, each turn can adjust itself to the strains upon it. The reduction in rotor diameter is a method of reducing the centrifugal stresses.

Rotor Couplings.—The difficulties of flexible couplings of the claw pattern, with excessive pressure upon the line of contact, together with defects in centering and of running balance, have caused a gradual adoption of solid flange couplings.

Stator Cores.—The problem of inadequate size of keys is a matter of more ample proportions, or of reversion to the original design of keys stamped out of the discs. The trouble of soft cores is usually due to the end plates being of insufficient stiffness, and as they are generally attached to the frame only at the periphery, there is a considerable spring across the face of the plate. In case of cores of considerable radial depth, one or more rings of insulated bolts may be necessary in addition, in which case all electrical contact with the bolt heads and nuts on the end plates must be carefully avoided. The bolts and nuts require countersinking to give free space for the end connections. The lack of support at the teeth is due to the narrow width of stiffening finger chosen to give the greatest area for the air current. Stronger I and ⊔ supports should be provided. Another and more complete remedy is considered later.

The remedy for soft cores resulting from inaccurate punching of the slots and keyways is obviously that of more accurate stamping.

Stator Windings.—Even with the most thorough lamination of conductors, no trouble usually occurs through lack of stiffness in the portion of the coil within the winding slot, except at the very extremities of the slot where displacement of the end connections may give rise to trouble. The difficulty of obtaining a firm wrapping upon a thoroughly laminated bar has been mentioned, and the remedy would appear to be less drastic division of conductors, or a better nesting together and impregnation before wrapping.

The end connections, if attached to weak laminated stator bars, are difficult to stay adequately. Usually fibre spaced blocks are laced between the ends of the stator bars at the junction with the end connectors; these give mutual support between the bars in a circumferential direction, but stresses on the short circuit are also radial from the centre, and in this direction the space blocks give but little support.

The remedy is to provide continuous coil supports having winding slots for the entire length of the end connectors. The terminal connections to each phase and to the neutral need not be further discussed.

Joints.—The risk of defective soldered joints has been dealt with. Soldered joints have of course the advantage of allowing easy disconnection for repairs at any time, but in the ideal machine under consideration no repairs would be necessary, and no joints would require disconnection until the generator went out of service with old age. Under these conditions all the joints would be fusion welded, except possibly in the case of the largest joints, where clamped and soldered connections would be permissible if well removed from the rotating field.

Heating and Fire Risks.—Owing to the limitations of air cooling, it has been argued that, provided suitable insulation can be found which will safely stand temperatures of 250 deg. to 300 deg. F., it is neither necessary nor desirable to limit the temperatures to lower figures. So far as is known, the only two insulating materials which can withstand such temperatures for any prolonged period without charring are mica and asbestos. As a rule, mica cannot be employed without a fibrous or paper backing on to which it is built by varnish or gums, whilst asbestos requires similar material to fill up the pores and render it suitable for insulation use. Such varnish or gums soften at temperatures approaching 300 deg. F. The melting-point of solder if used is also an important matter; for ordinary mixtures it is about 370 deg. to 390 deg. F.

Even assuming insulation difficulties are overcome, there remains the question of thermal expansion at these high temperatures. The respective coefficients for steel and copper for 1 deg. F. are: Steel, 600×10^{-8};

copper, 955 × 10⁻⁹. A steel rotor 80 in. long on the polar face, with a temperature rise from 60 deg. to 250 deg. F., will receive an increment of 0·0912 in., whilst the copper coil within the rotor slot will have an increment of 0·1452 in.; that is, the copper increases beyond the steel by 0·0540 in. in the rotor length of 80 in.

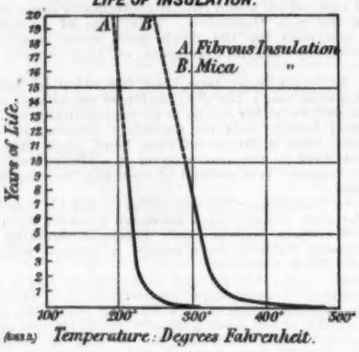
This increase, though very small, takes place whilst the coils are subjected to severe lateral pressure, and the effect of movement under such conditions will certainly shorten the life of the insulation.

The following figures on the resistance to crushing of mica are given by Professor Miles Walker:—

"Mica (pure white) 0·010 in. thick, when tested for crushing between copper plates, breaks down at 40,000 lb. per square inch, owing to the flow of copper. When tested between steel plates, it will withstand 90,000 lb. per square inch."

From these figures, it would appear that the slight movement of the copper plates is sufficient to flake and destroy the mica at a very reduced mechanical pressure. The effect of the probably greater and continued movement under thermal expansion cannot be otherwise than detrimental to the mechanical strength and life of the insulation.

Fig. 7. CURVE OF TEMPERATURE AND LIFE OF INSULATION.



The relation of the temperature to the useful life of the insulation is of great importance. Insulation secured in place and not subjected to mechanical stresses, such as that upon the separate turns of stationary field magnets, may be satisfactory, even when quite charred and devoid of any mechanical cohesion. With turbo-generators, the useful life of insulation practically ceases when it has mechanically failed.

The matter is briefly dealt with by Messrs. Steinmetz and Lamme.* Two curves are given, showing the relation of the useful life of insulation to the temperature, for:—

(A) Fibrous insulation, including fabric and paper; (B) mica and micanite insulation. The results have been reduced to Fahrenheit scale, and each curve has been continued to a hypothetical life of twenty years (see Fig. 7). There is clear indication that a reduced temperature gives a greatly increased life. During the past ten years long physical life of turbo-generators was not of great importance, as the continual reduction in steam consumption was sufficient to give a short economical life to turbo-generator plant. Such improvements in steam consumption are, however, now approaching a point when further considerable gains are difficult to accomplish.

It would appear that for large machines working continuously night and day for months together, a temperature of 150 deg. F. has much to recommend it from the point of view of capacity to meet sudden overloads and long life of insulation.

Having the fire risk in view, all inflammable packing insertion and all fibrous insulation should be avoided in both stator and rotor. The ideal insulation is yet to be found, but it would have a substantial body of mica built up without inflammable gum or varnish and with some degree of flexibility. The binding material of the mica and packing must have a high thermal conductivity and suitable specific inductive capacity to give a uniform electrical pressure gradient through the mass of insulation.

These suggested improvements have been more or less introduced into the latest designs of turbo-generators, but even the best of modern machines appears to stop short of the perfect generator.

(To be continued.)

CANADIAN INDUSTRIES EXHIBITION.—An exhibition exclusively devoted to Canadian industrial enterprises is to be held in June next in London. The exhibition has the support of the Canadian Trade Commission, the Canadian Manufacturers' Association, and the Canadian Mission in London. Most of the ground floor space at the Royal Agricultural Hall has already been definitely allotted to leading firms, the exhibits comprising grain elevators, separators, woodworking machinery, tractors, houses, hardware, steel products, &c., &c. All information can be obtained from the offices of the Exhibition, 43, Essex-street, Strand, W.C. 2.

* Transactions of the American Institute of Electrical Engineers, vol. xxxii, page 79.

TWO-SPINDLE SAW BENCH.

CONSTRUCTED BY MESSRS. THOMAS ROBINSON AND SON, LIMITED, ENGINEERS, ROCHDALE.

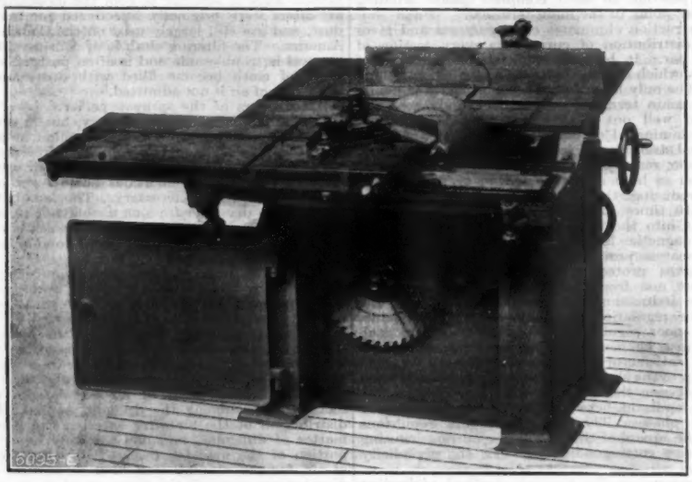


FIG. 1. MACHINE SHOWING THE TWO SAWS AND FRONT MOVING TABLE.

ON this and the opposite pages we give illustrations of a new two-spindle saw bench for dimension sawing, constructed by Messrs. Thomas Robinson and Son, Limited, Rochdale. This is a very neat machine suitable for a number of operations, and intended for pattern making, fine joinery, &c. It will cut compound angles, rough out core boxes, and will do ripping, cross cutting, grooving, mitreing, and so on. The illustrations show the machine ready for various operations. Fig. 1 shows the two saws mounted on their spindles, the cast iron door front of the machine being open for this purpose. The two saws are carried by spindles which run in bearings on a stiff revolving yoke. The front bearing takes the form of a disc which encloses completely all the working parts. The spindles are well lubricated whatever their position. The saws are driven by an endless belt arranged in such a way that it is only in contact with the spindle of the saw in use. The revolving yoke or frame carrying the saws is turned by machine cut worm gear. It is self-locking in all positions. Fig. 1 shows two saws fitted, 16 in. in diameter, one for ripping and one for cross cutting. The maximum projection of saws of this size above the table is 4¼ in. If a larger projection is needed a single 20 in. saw can be mounted, giving a projection of 6¼ in. above the table.

The table is 44 in. long and 40 in. wide. It can be canted as shown in Figs. 4 and 5, to 45 deg. This operation is performed by a worm and wheel. The angle is shown on an indicator on the side of the frame, clearly seen in Figs. 3 and 5. The front part of the table is a slide, moving on small rollers. It is 16 in. wide and can be fixed in any particular position by a spring stop. It is shown moved partly across the frame in Figs. 1 and 3. The movement of this slide is large enough to allow cross cutting up to 36 in. widths. The width of the saw gap may be increased so as to take a 2½ in. cutter block, for moulding, grooving, &c., or a special saw may be used for grooving. The fence is well supported and is carried on a slide, which can be best seen in Fig. 3. It can be quickly moved towards or away from the saw, over a distance which permits ripping up to 21 in. widths. The parallelism of the fence is assured by the slide working in a long slot. The width is gauged by a graduated scale, and a micrometer screw is fitted for fine adjustment. The fence can be canted to 45 deg., as shown in Fig. 5, while it can also be set to 30 deg. either way by the swivelling sector, and clamp just behind it on the slide, shown in Fig. 3. It can thus be used for roughing out core boxes. A single screw clamps the fence when canted, and it is located parallel to the saw by a taper pin.

In our Figs. 2, 3 and 4 the table will be seen to be fitted with a mitreing and cross cutting fence. This fixture is pivoted on the sliding table. It is graduated in degrees. A taper pin locates the principal angles. A long rod with an adjustable stop may be fitted to this fence, as may be seen in Fig. 4. This may be used for cutting off or mitreing lengths up to 36 in. On the floor in front of the machine, in Fig. 4, and in position on the table in Figs. 2 and 3, may be seen a small additional universal graduated guide. This may be used in sliding ways on either side of the saw. It is made to swivel, and is provided on its face with a steel sliding piece which supports the timber close up to the saw when the gauge is set at an angle. It can also be fitted with a rod carrying adjustable stops so that lengths can be repeated.

The machine is constructed for countershaft and belt shifting gear, either above or below floor level, or with electric drive. The pulleys on the saw spindles are 4½ in. diameter, and are designed for a speed of 2,500 r.p.m. Using a countershaft and 10 in. pulley, the countershaft speed should be 600 r.p.m. The floor space occupied, including countershaft, is 6 ft. 3 in. by 4 ft. 6 in.

INDUSTRIAL NOTES.

WE deal on another page of our present issue with the Government's offer for the standardisation of railway wages.

As stated in our last issue, the conference dealing with the moulders' strike was held last Friday, at the Ministry of Labour. At the close, the following official announcement was made:—

"The dispute at West Bromwich having been disposed of, it is jointly agreed to recommend—

"(1) The Engineering and the National Employers' Federation agree, as from the resumption of work, to pay an advance of 5*s.* on a full ordinary week to male workers of 18 years of age and over, members of the three unions, in accordance with the terms of the general engineering award of the Court of Arbitration dated November 5, 1919. Future general alterations in wages shall be dealt with in accordance with provisions for avoiding disputes to be mutually agreed upon.

"(2) The resumption of work shall take place by January 19, 1920. It may be possible, by reason of special conditions, to arrange for resumption between January 12 and 19, and in such case individual arrangements will be made. It must be recognised that it will not be possible to secure complete resumption by the dates named. The employers will, however, re-employ their workpeople as rapidly as the foundry circumstances will permit, and new workers will not be taken on so long as those workers who were in the same employment before September 20, 1919, are available, providing such workers present themselves for re-employment not later than January 19.

"(3) No victimisation shall take place on either side."

The above recommendations were signed on behalf of the Engineering and National Employers' Federations, the Friendly Society of Ironfounders, the Amalgamated Society of Coremakers, and the Iron, Steel and Metal Dressers' Society. The men had formerly rejected the offer of a 5*s.* advance. The representatives of these three unions who took part in the conference issued a statement to the men saying it was obvious that no general advance in excess of 5*s.* was at present obtainable. "In these circum-

TWO-SPINDLE SAW BENCH.

CONSTRUCTED BY MESSRS. THOMAS ROBINSON AND SON, LIMITED, ENGINEERS, ROCHDALE.

(*For Description, see opposite Page.*)

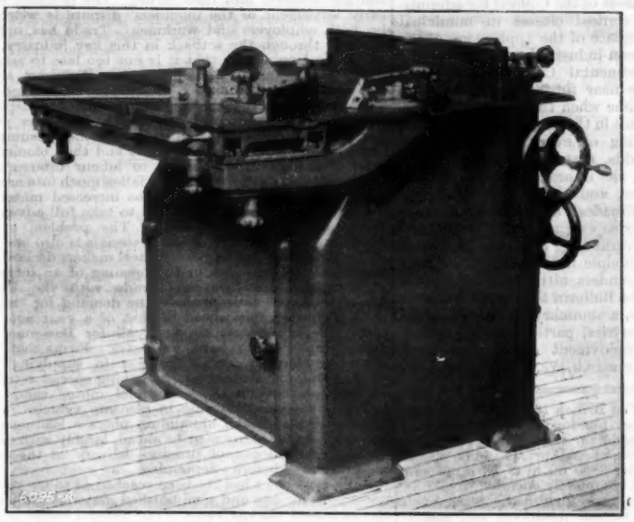


FIG. 2. SIDE VIEW OF MACHINE WITH TABLE LEVEL.

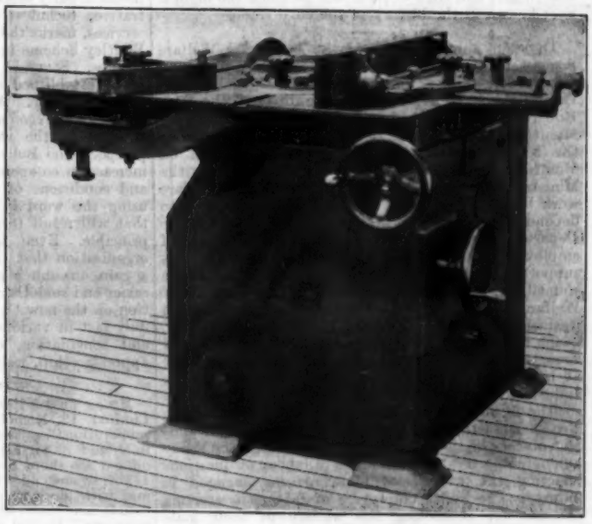


FIG. 3. BACK VIEW OF MACHINE WITH TABLE LEVEL.

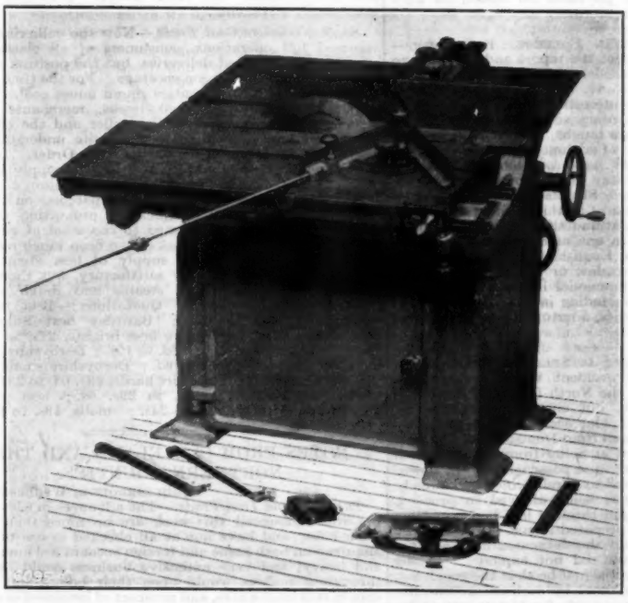


FIG. 4. FRONT VIEW OF MACHINE WITH TABLE CANTED.

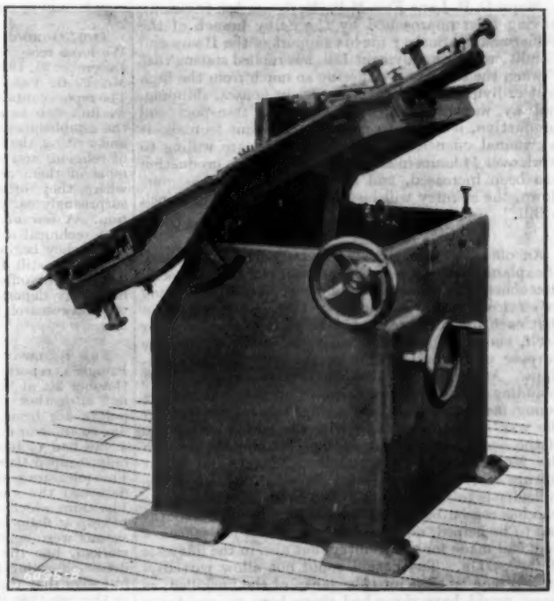


FIG. 5. BACK VIEW OF MACHINE WITH TABLE CANTED.

stances," they added, "your representatives could not take the responsibility of terminating the negotiations. It was only after long and anxious consideration that we agreed to take a ballot on the proposals. The committee consider that they would not be properly discharging their duty if they did not strongly urge the members to accept the proposed settlement, because they are quite convinced that there is not the slightest prospect of the continuation of the strike resulting in any improvement of the terms recommended for acceptance." The said recommendations were submitted to a ballot of the men on Monday and Tuesday. At the time of going to press, the full figures are not available, but the majority so far is against acceptance.

"The American plan of employment," another name for the "open shop," as promoted by the Associated Industries of Seattle (Washington), has attracted universal attention along the Pacific Coast, says *The Iron Age*. It has resulted from the general strike in February which paralysed the principal industries of that city and threatened the city's economic destruction, and has led to the formation of the Associated Industries of Seattle, to fight the radicals in industry who were striving to wrest control from their employers. At first, the Associated Industries gave the unions a chance to "clean house" and expel their radicals, but when the unions failed to do this, the organisation demanded and obtained purely open shops. Co-operation was received from the Chamber of Commerce, clubs and all other civic and commercial organisations of the city. Advertisements were published in the leading dailies which influenced public opinion. The movement is not against unionism, but against the domination of unionism and industry by un-American radicals. The unions have now lost control in rapid succession of the building industry, the job printing industry, the master pile drivers and various other trades. Public sentiment is now strongly in favour of the open shop. San Francisco, Portland, Spokane and Tacoma have organised Associated Industries on the Seattle plan.

We have received a copy of the first issue of *The Woman Engineer*, for December last, an 8-page quarto journal, the object of which is both to encourage and stimulate all women who are interested in engineering, and to remove the prejudices and artificial restrictions which now prevent women from taking up engineering as a trade or profession. It is published by The Women's Engineering Society, 46, Dover-street, Piccadilly, W. 1, who hope to issue it quarterly during the first year.

It is reported by *The Iron Age* that from December 1, practically all the coke operators in the Connels-

ville and adjacent regions granted their coal miners and coke workers an average advance of 14 per cent. in wages, this being the same amount granted by the Fuel Administration to the striking coal miners. This is the largest single advance in wages ever made in the history of the Connelsville coke region, previous advances having ranged from 5 per cent. to 10 per cent. Under the terms of this new wage scale, wages of coal miners and coke workers will be much the highest ever known in the history of the coke trade.

The first annual report of the Industrial Welfare Society, for the year ended June 30, 1919, has now been issued. The history of the society is the following: During the early part of 1916, the director, the Rev. Robert R. Hyde, was invited by the Ministry of Munitions to initiate a scheme of welfare work for the benefit of the thousands of boys engaged on Munitions. The Director, after two years spent at the Ministry, came to the conclusion that for the welfare work to remain a living force in industry, it had to depend for its direction and control not upon a State Department, but upon the goodwill and experience of employers and representatives of labour. He was supported in this view by the original members of the council, and, at a meeting held in July, 1918, the Boys' Welfare Association was formed. The organisation was carried on under this name until May, 1919, when, owing to representations made from various influential sources, it was decided to enlarge its scope to embrace all industrial workers, and to change the name to the Industrial Welfare Society. The chairman of the society is Sir William Beardmore, and many leading British industrialists are on the council. The aims and objects of the society are to encourage the study among employers and managers of labour of questions affecting the welfare of male persons engaged in industry; to assist employers of labour in starting schemes for promoting the welfare of their male employees; to arrange meetings and conferences, and to publish a magazine, for the exchange of views and experiences with regard to these questions.

Major G. R. Lane-Fox, M.P. (Barkston Ash Division), having been approached by the Selby branch of the Boilermakers' Society for his support of the Hours and Conditions of Employment Bill, has replied stating that "when the country is suffering so much from the high cost of living, due to the shortage of houses, shipping, railway wagons, and other means of transport and production, it seems to me a bad moment to make it a criminal offence to employ men who are willing to work over 44 hours in any one week. When production has been increased, and the cost of living has gone down, the country will be better able to consider such a Bill."

An official of the Ministry of Labour, in the course of explanations to a representative of the Press Association concerning the working of the movement for aiding ex-service youths to complete their training, states that each industry was asked to prepare a scheme for itself, embodying certain minimum conditions for the purpose of facilitating the completion of apprenticeships. At the present time, about 40 separate schemes, including about 800 trades, are in operation for aiding young men whose apprenticeship was interrupted by the war. The apprentices who are taking advantage of the conditions offered by the Government through the Ministry of Labour number 23,000, and about 800 are accepted every week. In certain instances, the difficulty is to find an employer to take the place of one who has ceased business. It was felt that these youths had to be helped, not simply in return for the sacrifices they had made for the country, but also in the interests of the nation. The nation could not allow partially-trained men to drift into the ranks of the unskilled, as many would have done had there been no assistance forthcoming. Every scheme provides for, at least, the following: An apprentice who was in his last year on enlistment to be treated as though his apprenticeship had terminated and to be paid as a journeyman; the completion of the apprentice's training; the reduction, by not less than one-third of the time spent in the Forces, of the period which the apprenticeship had to run on the apprentice's enlistment; payment to the apprentice who had reached 21 years of age, or the age when his original apprenticeship should have terminated, of not less than three-fourths of the journeyman's wage for the first half of the training and five-sixths for the remainder; the State to pay one-third of the journeyman's wage in respect of each man coming under the preceding paragraph.

The Bulletin No. 2, for December, issued by the Industrial Councils Division, Ministry of Labour, shows that 51 Joint Industrial Councils were set up in as many industries throughout the Kingdom, down to October 21 last. It states that the outstanding feature of the past three months in the application of the Whitley Committee's recommendations has been the establishment of three National Councils on which the Government as employer is represented. There is also progress to report in connection with the establishment of Industrial Councils for the War Office and the Ministry of Munitions. The Admiralty and the Office of Works' Councils have held their first meetings. The Civil Service Council has met twice, which, with the probable early establishment of the Council for administrative, technical and clerical classes in municipal services, marks the emergence of the application of the Whitley Scheme in the non-industrial and professional spheres. Several Departmental Councils are likely to be established in the near future under the Civil Service Scheme. At a time when the efficiency of this country as an economic unit in the community of nations is vital to the well-being of every individual, the prospect, the Bulletin adds, may be welcomed of the increase in co-operation, the improvement in methods and conditions of labour, and the gain in wealth—using the word in its broadest and best meaning—that will result from a wise extension of the Whitley principle. Even the overhauling of our industrial organisation that the principle necessitates is in itself a gain, inasmuch as it renders ultimate co-operation easier and smoother. The Bulletin then gives information on the new Councils, a summary of progress since July last in various industries, particulars of disputes and conciliation, on employment of disabled men, apprenticeship, welfare, research, &c.

MILAN TRADE FAIR.—The British Italian Corporation, Limited, 12, Nicholas-lane, London, E.C. 4, state that preparations are being made for holding a Trade Fair in Milan for a fortnight, from about April 12. The stands offered are shops measuring 3·50 m. by 3·50 m. (about 11¼ ft. square) floor space, completely enclosed, roofed in and with glass fronts, but not furnished. Sixty such stands are reserved for British producers and manufacturers. Roofed sheds and out-door open spaces are also offered for machinery and large exhibits. The corporation has been appointed agent of the Fair Committee for the British Empire, and is authorised to receive applications and payment for space, to allot stands, and to reply to inquiries.

THE GORDON MEMORIAL COLLEGE, KHARTOUM.—We have received a copy of the report and accounts to December 31, 1918, of this college, from the hon. secretary, Mr. F. G. Van de Linde, 67, Lombard-street, E.C. 3. The report contains many interesting data. For example, we find that in the elementary schools forming part of the establishment, boys are taught, besides drill, reading and writing, the four rules of arithmetic and the elements of religion, and when they have completed this course, most of them naturally stay on in their own villages, where they often become Sheikhs and Omdas at a surprisingly early age, thanks to this elementary education. A few of them continue their education, either in a technical school or in one of the primary schools, where they begin to learn English and to fit themselves either for still further studies or for employment in Government offices or commercial houses. The college has many departments, including industrial workshops, tropical research laboratories, a natural history museum, &c.

THE RAILWAY ACCIDENT AT SELBY.—Colonel J. W. Pringle's report on the accident which occurred on October 30, at Selby, on the North-Eastern Railway, is not altogether conclusive, but one or two interesting points are brought out. The accident was primarily due to an error in a telegram from Doncaster saying that a van had to be detached at Selby from a train which only stopped there if there were passengers to set down. This telegram really referred to a train which had already detached the van and was being allowed to proceed. The train which usually ran through had had no orders to stop at Selby and was prepared to run through. The signals were against it and the detonator machine was worked, but the detonator did not explode. On the driver observing the danger signal he shut the regulator, but says that this was followed by such smoke and fire in the cab that it was impossible for him to get at his brake handle. The fireman put on the jet, and closed the damper. Colonel Pringle thinks the driver's account of the so-called backfire exaggerated and that if the fireman could operate the blower and damper, he ought to have been able to get at the brake. The inspector does not consider the backfire to have been serious. He suggests that the type of detonator machine used in which the detonator is tied to a wooden arm, to be unsatisfactory; that something should be done to reduce the risk of backfiring and the emission of smoke, &c., on the footplate; and that automatic stop signals should be given more consideration. It may be added that the "backfire" was traced to be due partly to the fact that the jet pipe had become disconnected from its mounting, and that the steam escaping when the valve was opened instead of being directed up the chimney, would blow round the smoke-box and back along the tubes. He suggests the coupling of the regulator and blower so that when the regulator shut the blower would open. Such an arrangement could not take the form of a permanent connection or the blower would often be working when not required. The type of door in which the centre portion acts on a hinged deflector plate, is not altogether satisfactory in the case of a blow-back, as it is not anything like airtight, and allows a great deal of smoke to escape.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Until Monday, no serious attempt was made to resume iron and steel production or engineering activity. To-day, work is progressing on a restricted basis. Orders have accumulated during the holidays, and there are many arrears to wipe off, but a resumption of foundry supplies is essential before the staple trades can get properly into their stride. The prospect of an early settlement of the moulders' dispute is welcomed by both employers and workmen. Trade has suffered severely through the setback in this key industry, but the general opinion is that it is not too late to retrieve the loss sustained. Responsible manufacturers are of the opinion that if output is allowed to proceed uninterrupted in all the iron and steel branches, prosperous conditions are assured for the next two or three years. The demand for open-hearth steel for home consumption and for shipment to the Continent and the Colonies has reached a high level. Owing to labour interruptions and traffic delays, deliveries have fallen much into arrears, and production will require to be increased materially if local makers are to be enabled to take full advantage of the increased requirements. The problem of the deficiency in the supply of raw materials is also one that will require early adjustment. Steel makers declare that the easiest solution lies in the opening of an increased number of blast furnaces. Trade with the United States continues to improve. The demand for crucible steel is considerably ahead of that of a year ago, and there is also a much stronger call for Bessemer and Siemens steel sheets, bars and plates. Firms that were specially engaged during the war in supplying aero engines and aeroplane steel, are paying special attention to the construction of commercial motor cars. One concern that is specialising in pleasure vehicles in the construction of which aluminium plays a leading part, is booked up for many months ahead, largely with orders for France, and cannot promise delivery of the latest requirements before September of next year. No definite agreement has yet been reached as to the revised quotations for raw and semi-finished materials, following the increased railway rates. The general belief is that pig-iron will advance 5*s.* to 7*s.* 6*d.* per ton, and that manufactured steel will move up 1*l.* 15*s.* to 2*l.* 5*s.* per ton. The improvement in the market for special steels, and especially for high-speed steel, is indicated in the renewed demand for steel alloys. Quotations are accordingly advancing.

South Yorkshire Coal Trade.—Now the collieries have resumed full operations, consumers of all classes are pressing for increased deliveries, but the position is still largely ruled by the wagon shortage. For the time being the principal difficulty centres round house coal. With substantial arrears on their books, merchants voice strong regret that the Coal Controller and the colliery companies have not come to a definite understanding respecting the translation of the new Order. In the meantime it is unlikely that collieries will supply fuel at 10*s.* a ton reduction when they can secure a much higher rate for the same fuel if despatched on manufacturing account. A considerable proportion of the new output has been allocated to the relief of gas and electricity plants, whose stocks have been much reduced during the holidays. The supply of best steams for industrial purposes is fairly satisfactory, but there is a distinct shortage of small steams and rough slacks. Coke is a strong market. Quotations:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.*; Derbyshire best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The advances in Cleveland pig-iron announced this week are no more than were looked for, and have not at all checked desire to buy. Inquiries on both home and foreign account are numerous and heavy, and very extensive business could be put through if makers would open their books, but with supply still inadequate, and prospect of increased demand producers are disinclined to commit themselves to any great extent. The advance of 15*s.* makes No. 1 Cleveland pig-iron 182*s.* 6*d.* and No. 3 and all the lower qualities 175*s.* for home consumption. Quotations for shipment to France, Belgium and Italy are 5*s.* above the foregoing rates, but there is now an open market for business with all other countries, and for such transactions up to 200*s.* is named for No. 3.

The Public Warrant Stores.—Stock of pig-iron in the public warrant stores has practically disappeared. Since September 2, 1918, the quantity held has stood at only 250 tons of No. 3 Cleveland pig-iron, and it has now been decided to cease publishing the stock returns.

Hematite Iron.—The advance in East Coast hematite announced this week is 20*s.* per ton. Thus No. 1 becomes 222*s.* 6*d.* and mixed Nos. 220*s.* for home use. Conditions as regards export trade are the same as rule in Cleveland pig-iron. Demand for hematite is good, and expansion of trade is looked for.

Coke.—Coke continues scarce and strong. As yet average blast-furnace kind is still put at 48*s.* at the ovens, but a rise of 2*s.* 6*d.* is expected to be announced at any time. Quality low in phosphorus is 53*s.* at the ovens.

Ferro-Manganese and Spiegel.—Advances in quotations to home consumers have also been made in ferro-

manganese, and spiegel irons. The former has been raised by 30*s.* and the latter by 20*s.* This makes ferro-manganese 28*l.* 10*s.* delivered at buyers' works, and spiegel 16*l.* 10*s.* delivered at buyers' works.

Foreign Ore.—Values of foreign ore show marked upward tendency, and sellers expect to do considerable business at advanced rates. Their position is strengthened by the high and still rising freights.

Manufactured Iron and Steel.—Manufacturers of finished iron and steel have far more work on hand than they can cope with, and not only is pressure for delivery against contracts made, unabated, but inquiries are on an enormous scale. Further advances are confidently anticipated, and for the time being there is practically no selling. To home customers the following nominal rates are amongst the principal market quotations:—Common iron bars, 22*l.* 10*s.*; marked bars, 25*l.* 10*s.*; steel plates, 18*l.* 15*s.*; steel angles, 18*l.* 5*s.*; steel joists, 18*l.* 5*s.*; and heavy sections of steel rails, 17*l.* 10*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

General Trade.—The annual New Year holidays are now nearly over and many industries have already commenced operations. Repairs and overhauls have been carried through as expeditiously and thoroughly as possible, and plants have been prepared for the strenuous time ahead. Nearly all branches of industry throughout the country are in a very healthy condition at the present time, and the New Year has started with order books well filled and consumers crying out for deliveries. The iron, steel, engineering and textile trades are all busy, and have plenty of work booked to keep them going steadily for months to come, and the prospect generally is indeed very bright. What seems to be the most disturbing factor at the moment is the increase in railway goods rates, which comes into force shortly, but buyers will soon become used to the new state of affairs and business will once again settle down and proceed along the new lines. The fear of further trouble with the railwaymen is not being looked upon with other than mixed feelings, and it is to be hoped that the latest offer will be accepted by all without any attempt to force further concessions by means of a strike. Labour has gained so much during the past year that one would fain hope that during the present year both sectional and general stoppages will be unknown, and that employees will assist masters in every way possible to meet the great competition which we are promised from America and the Continent by a much larger output.

Scotch Steel Trade.—A start has now been made in the steel trade of Scotland, and reports show that it has been very good, but it will be the beginning of next week before work is really general. Inquiries have been accumulating and, although prices are all tending upwards, quite a large tonnage could be added to order books if anything like reasonable delivery could be promised. The latter is still the difficulty on account of the arrears of business which have yet to be cleared off. All classes of material are in great demand, ship and boiler plates, sections, black sheets, &c., and for some time all plant will be kept running at top pressure. Several manufacturers are so fully booked up that for the present they do not feel justified in quoting.

Malleable Iron Trade.—The malleable iron makers in the West of Scotland have plenty of work on hand to keep them busy from now onwards, and the output would be considerably increased if more labour could be secured. Although active conditions ruled during the past year, and whatever was on offer was quickly taken up, a larger tonnage would have been available had it been possible to get more men to operate furnaces which were recently lying idle. Perhaps this may be remedied in the near future, and the demand from abroad met as inquiries for shipping lots are again very good.

Scotch Pig-Iron Trade.—In the Scotch pig-iron trade the prospects are quite satisfactory, and there are many inquiries presently in the market, amounting to a large tonnage. Prices are again stronger, and with the advance in railway rates a still higher level will be touched. The demand for the best brands is again noticeable, but the scarcity of these continues. Hematite, which was recently so much in demand, is the subject of good inquiries, and no difficulty will be experienced in getting rid of this even at the advanced prices desired.

Scotch Shipbuilding.—The shipbuilding returns from the different Scotch centres for the past month were fairly satisfactory, and the actual output for the year makes 1919 rank well amongst its predecessors. For the twelve months the figures were as follow:—

	Vessels.	Tons.
The Clyde	422	646,154
The Forth	42	51,280
The Tay	13	17,765
The Dee	68	13,488
Total for 1919	545	728,687
Total for 1918	585	613,709

The total increase in tonnage for the past year over 1918 is thus 114,978 tons. Taking the Clyde figures for the year, nine fewer vessels were launched, but the total tonnage shows an increase of 114,060 tons. The total output is much better than was at one time anticipated it would be, and places the year 1919 second only to the record year 1913, when the total tonnage was 756,976, which was the only occasion when the 700,000-ton mark was reached. On three occasions the years's output has exceeded 600,000 tons, these being 1907, 619,919 tons; 1911, 630,583 tons; and 1912, 640,529 tons. When we consider the odds which have had to be faced during the past year—labour discontent, shortage of supplies, and the changing over from war to peace conditions—the total of new tonnage must be considered very satisfactory indeed. A very large proportion of it was for cargo-carrying purposes, whereas the bulk of contracts at present on hand are of the liner class. This year opens with very encouraging prospects, and if there is little disturbance in the labour market during the next twelve months there ought to be a record output from the Clyde shipyards. Order books are well filled, and with the world's demands for merchandise being on the increase shipyards should be kept working at top pressure.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Coal Market.—Coals of all grades remain extremely scarce and prices are steady at record levels. Collieries generally are fully sold over the month, and have ample shipping in dock, and therefore are not in need of fresh business. In fact, many are out of the market and are obliged to turn down new business. The requirements of inland consumers remain heavy, and large quantities are allocated, and in consequence the amount available for export is considerably reduced. Large quantities are also being sent to the home ports by steamer, and this tonnage is given preference in loading to the detriment of foreign-going tonnage. The docks are crowded with vessels, some of which have been waiting since before Christmas for tips, and loading accommodation is at a premium. Prices depend largely on individual circumstances, and actual business is confined to the picking up of small parcels. Best Admiralty large is firm at 110*s.* per ton, with Monmouthshire and dry large at 105*s.*, and ordinary large from 100*s.* up. Smalls are particularly scarce, with best steams from 85*s.* to 90*s.*, ordinaries round 80*s.* and inferiors from 65*s.* up. Coke and patent fuel are practically unobtainable, makers having already sold almost the whole of their output. Coke has realised up to 120*s.*, and sellers are now asking 125*s.*, while patent fuel ranges from 105*s.* to 110*s.*, business having been transacted at both figures. Pitwood is very scarce, and importers find no difficulty in obtaining 75*s.* for the small lots available. Exports of coal last week totalled 340,186 tons, of which 229,475 tons was sent from Cardiff, 62,161 tons from Newport, 29,023 tons from Swansea, and 19,582 tons from Port Talbot.

The Iron and Steel Trades.—The tin-plate market maintains its firmness, though operators fear that now the American mills are getting back to work competition will result in a fall in prices, though this is not expected for some time, as the Americans have heavy arrears to wipe off. The basis box of tin plates has realised up to 56*s.* for prompt delivery and 52*s.* for delivery in the third quarter of the year. There is an active demand on foreign account. Owing to a shortage of steel bars a number of works have been obliged temporarily to close down, but it is expected that an early re-start will be made. The shortage of bars is due to difficulty in transport and scarcity of coal. Galvanised sheets are in good demand, with prices firm at 57*l.* for 24-gauge corrugated, in bundles. Sheets and tin bars are firm at 18*l.*, with the tendency towards higher levels. The Duffryn Steel and Tin-plate Works at Morriston have been acquired by Mr. Llewellyn Davies, of Gorseinon, and Mr. F. R. Phillips, of Pontadawe, and the purchase price is stated to approximate 750,000*l.* These works are amongst the largest and most important in the trade. Tin-plate workers have made an application for a 50 per cent. increase in wages, but though prices are high, working costs are also high, and makers are of opinion that the trade will not stand such an advance.

NON-FERROUS MATERIALS.—The following particulars are published of the stocks (exclusive of old metal and scrap) in this country in possession of the Minister of Munitions on January 1: Copper, 10,095 tons; spelter, G.O.B., 10,318 tons; spelter, refined, 9,754 tons; aluminium, 7,084 tons; soft pig lead, 54,975 tons; nickel, 1,650 tons; antimony regulus, 2,775 tons. A proportion of the above stocks is already sold to the trade for forward delivery.

ROLLS-ROYCE FACTORY IN AMERICA.—The works of the Wire Wheel Corporation, Springfield, Massachusetts, have been purchased by Rolls-Royce of America, Incorporated, for the purpose of making there the Rolls-Royce cars. The new company is controlled by Rolls-Royce, Limited, of England, seeing that they have the majority of the votes and the majority on the Board. The principal officials of Rolls-Royce, Limited, in England hold corresponding posts in the American Company. The British and American companies are to work hand in hand.

THE MICROSCOPE; ITS DESIGN, CONSTRUCTION AND APPLICATIONS.—A meeting convened by the Faraday Society, the Royal Microscopical Society, the Optical Society and the Photomicrographic Society, in co-operation with the Optical Committee of the British Science Guild, will be held on Wednesday, the 14th inst., in the rooms of the Royal Society, Burlington House, Piccadilly, and will deal with "The Microscope; Its Design, Construction and Applications." It will extend over two sessions, from 4.30 to 6.30, and from 8 to 10 p.m. During the afternoon, from 2.30 to 4.30, an exhibition will be held in the Library of the Royal Society, to illustrate recent developments in the science of microscopy, and the latest applications of the microscope in all branches of industry. Sir Robert Hadfield will preside over the meeting.

NOTICES OF MEETINGS.

THE MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday evening, January 10, at the Grand Hotel, Aytoun-street, when a paper on "Cast-Iron in Theory and Practice" will be read by Mr. E. Adamson, Sheffield. The chair will be taken at 7 p.m. prompt.

THE SURVEYORS' INSTITUTION.—Monday, January 12, when papers will be read by Mr. E. M. Konstam, K.C., O.B.E., and Mr. C. H. J. Clayton, M.B.E., on "Land Drainage from the Administrative and Engineering Points of View." The chair will be taken at 8 p.m.

THE BRADFORD ENGINEERING SOCIETY.—Monday, January 12, at 7.45 p.m., in the Hall of the Bradford Technical College, when a lecture will be given by Lieutenant-Colonel W. Lockwood Marsh, O.B.E., M.A., LL.B., A.F.R.Ae.S. (Secretary, Royal Aeronautical Society), on "Some Points in Airship Design."

THE CERAMIC SOCIETY.—Monday, January 12, at 7.30 p.m., in the Central School of Science and Technology. The meeting will take the form of a "Symposium on Unestimated Losses in Pottery Manufacture."

CLEVELAND INSTITUTION OF ENGINEERS.—Monday, January 12, in the Hall of the Cleveland Literary and Philosophical Society, Corporation-road, Middlesbrough, at 6.30 p.m. Paper on "Standard Marine Engines," by Mr. E. Hall-Brown, Middlesbrough.

THE INSTITUTION OF ELECTRICAL ENGINEERS (NORTH MIDLAND CENTRE).—Tuesday, January 13, at 7 p.m., Meeting at the Metropole, King-street, Leeds. Paper by Messrs. A. G. Ellis and J. L. Thompson, "Large Power Transformers."

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, January 13, at 5.30 p.m. Papers to be submitted for discussion: "Whitby Harbour Improvement," by Mr. James Mitchell, M.Inst.C.E.; "The Design of Harbours and Breakwaters with a View to the Reduction of Wave-Action within Them," by Mr. Ralph Frederick Hindmarsh, M.Inst.C.E.; "Wave-Action in Harbour Areas; with Special Reference to Works for Reducing it at Blyth and Whitby Harbours," by Mr. John Watt Sandeman, M.Inst.C.E.; "The Improvement of the Entrance to Sunderland Harbour, with Reference to the Reduction of Wave-Action," by Mr. William Simpson, O.B.E., M.Inst.C.E.—Students' Meeting, at 6 p.m., Vernon-Harcourt Lecture on "The Economic Requirements for Inland Navigation Transport in the British Isles," by Mr. R. B. Dunwoody, Assoc.M.Inst.C.E.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN.—Tuesday, January 13, at 7.30 p.m., at the Arts Building, Liverpool University, Mr. S. Clowes, Wh.Ex., on "Elementary Calculus," being the fifth lecture of series. Thursday, January 15, at 7.30 p.m., in the Engineering Lecture Theatre, Liverpool University, Mr. M. Coronel, on "Gearing Design," being an official Association Lecture; at 7.30 p.m., at the Grammar School, Chesterfield, Mr. Frank S. Marsh, M.Sc.(Leeds), B.Sc.(London), on "Gas Cylinders." Friday, January 16 at 8 p.m., at Y.M.C.A., Bothwell-street, Glasgow, Mr. M. Coronel on "Gearing Design"; at 7.15 p.m., at Y.M.C.A., Blackett-street, Newcastle-on-Tyne, Mr. W. Roland Needham, on "Critical Speed of Shafts," being an official Association Lecture; at 7.30 p.m., at Applied Science Department, Sheffield University, Mr. Frederick Clements, Wh.Ex., M.I.Mech.E., on "Principles and Design of Centrifugal Fans."

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, January 14, at 7.30 p.m. Paper by Mr. T. E. Gregory, on "Currency, Finance and Industrial Trading." Mr. H. G. Williams, M.Sc., M.Eng., A.M.I.C.E., in the chair.

THE BIRMINGHAM METALLURGICAL SOCIETY.—Thursday, January 15, at 7 p.m., at the Birmingham Chamber of Commerce, New-street. Paper by Mr. H. J. Coe, M.Sc.(Swansea), "The Heat Treatment of Medium Carbon Steels."

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 16, at 7.30 p.m., at 39, Victoria-street, S.W. 1. Chairman's Address, "Meteorology and Engineering," by Mr. B. E. Dunbar Kilburn, M.A.Camb.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, January 16, at 9 p.m., a discourse will be delivered by Professor Sir James Dewar, LL.D., D.Sc., F.R.S., M.R.I. The subject is "Low Temperature Studies." Afternoon Lectures, at 3 p.m.: Tuesday, January 13, Sir John Cadman, K.C.M.G., D.Sc., M.Inst.C.E., on "1. Modern Development of the Miner's Safety Lamp"; Thursday, January 15, Mr. Richard R. Terry, Mus.Doc., F.R.C.O., on "Renaissance Music in Italy and England" (with musical illustrations) (Lecture I); Saturday, January 17, Mr. Alfred Noyes, on "1. The Anglo-American Bond of Literature."

THE INSTITUTION OF ELECTRICAL ENGINEERS (SCOTTISH CENTRE).—At the Princes-street Station Hotel, Edinburgh, Major Theo. Rich, O.B.E., will deliver a lecture, entitled "Electricity in the Western War Zone."

ARMSTRONG-SULZER MARINE DIESEL ENGINE.—Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, have entered into an agreement with Messrs. Sulzer Brothers, Winterthur, whereby they acquire a licence to manufacture and sell in Great Britain and the Colonies two-cycle marine Diesel engines embodying the best features of the Sulzer system. It has been decided to adopt the two-cycle principle on account of the proved reliability and efficiency of this type of engine, its high ratio of horse-power to size and weight, and its ability to work continuously on Californian or Mexican crude oils of high sulphur and asphalt content, these being the cheapest crude oils at present on the market.

THREE-CYLINDER 0-8-0 TYPE SUPERHEATER LOCOMOTIVE; NORTH-EASTERN RAILWAY.

CONSTRUCTED AT THE COMPANY'S DARLINGTON WORKS, TO THE DESIGN OF SIR VINCENT L. RAVEN, K.B.E., M.INST.C.E., CHIEF MECHANICAL ENGINEER.

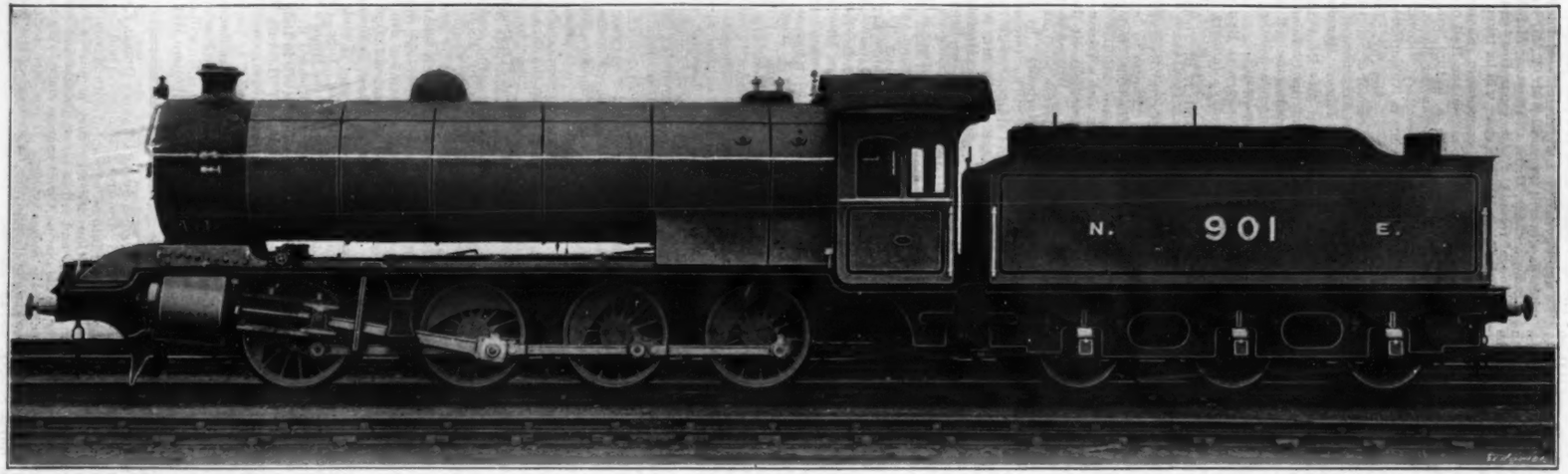


FIG. 1.

In Fig. 1 herewith, and Figs. 2 and 3, on Plate II, with this week's issue of ENGINEERING, we illustrate a new class of 0-8-0 locomotives designed by Sir Vincent L. Raven, K.B.E., for the North-Eastern Railway Company, of which he is the Chief Mechanical Engineer. These locomotives have been built at the company's works at Darlington, and are intended for mineral traffic in the Newcastle district. They are designed to deal with trainloads of 1,400 tons on gradients of 1 in 20.

As superheater locomotives with three 18½-in. by 26-in. cylinders these engines are very powerful machines for English practice. Apart from the cylinder arrangement the design does not present many departures from the normal. The cylinders are in three castings, two being outside the 1⅛-in. slab frames and one casting forming a common steam chest for all three cylinders together with the central cylinder, extending between the frames. The valves are in all three cases piston valves, 8¼ in. in diameter, worked by ordinary link motion. The exhaust chambers are separate up to the base of the blast pipe. The working pressure of the boiler is 180 lb. per square inch, and at 85 per cent. the maximum tractive force works out at 36,963 lb.

The boiler barrel is composed of three rings, 5 ft. 6 in. in outside diameter. The barrel is 15 ft. 10½ in. long, the length between tube plates being 16 ft. 2⅝ in. The fire-box is 9 ft. long by 3 ft. 11 in. wide. The fire-box and ash pan are carried over the trailing axle. It will be noticed that liberal mechanical lubrication is provided for the main journals, especially for the trailing axle under the fire-box. Power reversing gear is fitted. The engine is fitted with Schmidts superheater, particulars of which, with other data, are given in the tabular statement annexed.

Locomotive.			
Cylinders, number	...	...	3
Do. diameter	...	...	18½ in.
Do. stroke	...	...	26 in.
Wheels, diameter	...	...	4 ft. 7½ in.
Wheel base	...	...	18 ft. 6 in.
Boiler diameter	...	...	5 ft. 6 in.
Do. length of barrel	...	...	15 ft. 10½ in.
Fire-box, length	...	...	9 ft.
Do. width	...	...	3 ft. 11 in.
Tubes, boiler, number	...	...	192
Do. boiler, diameter	...	...	2 in.
Do. smoke, number	...	...	24
Do. smoke, diameter	...	...	5½ in.
Do. length	...	...	16 ft. 2⅝ in.
Heating surface, boiler tubes		...	876 sq. ft.
Do. smoke tubes		...	531 sq. ft.
Do. fire-box		...	166 sq. ft.
Do. total	...	...	1,573 sq. ft.
Superheating surface	...	...	530 sq. ft.
Working pressure	...	...	180 lb. per sq. in.
Grate area	...	...	27 sq. ft.
Length (Frame)	...	...	35 ft. 6 in.
Weight in working order		...	71 tons 12 cwt.
Tender.			
Coal capacity	...	...	5½ tons.
Water capacity	...	...	4,125 gallons
Weight	...	...	44 tons 2 cwt.
Engine and Tender.			
Total weight in working order		...	115 tons 14 cwt.

PITWOOD ORDER, 1919.—The Board of Trade announce that the Pitwood Order, 1919, has been revoked as from the 2nd inst.; all restrictions with regard to supplies and prices of pitwood are accordingly removed.

SLAG WOOL LAGGING FOR STEAM PIPES.—Messrs. Frederick Jones and Co., Ltd., Kentish Town, London, N.W., have sent us a pamphlet giving the results of some tests carried out at the National Physical Laboratory, on slag wool as a lagging material for steam pipes. The tests were carried out on a 4-inch steel steam pipe 13 ft. 8½ in. long between flanges. The thicknesses of wool used were 1 in. and 2 in., and these were each tested at three pressures, viz., about 54 lb., 108 lb., and 256 lb. per square inch. In the case of the 1-in. covering the saving with 53·9 lb. pressure, over the bare pipe amounted to 84·9 per cent. With 109·2-lb. pressure it was the same and with 256·3-lb. pressure the saving shown was 85·5 per cent. In the case of the 2-in. covering the saving was naturally higher. At 54·1-lb. pressure it was 91·8 per cent., at 107·8 lb. it was 91·6 per cent., and at 258·9 lb. 92·5 per cent., showing the efficiency of this material as an insulator.

BULLETIN OF THE INTERNATIONAL RAILWAY ASSOCIATION.—We are pleased to be able to welcome the re-appearance of the Bulletin of the International Railway Association (English Edition). The publication of this bulletin was interrupted by the war, and the number which now appears is the first of a new series which, however, resembles its predecessors in size and style, so that, for library purposes, the two series will be uniform. The Central Empires at the time of the occupation of Brussels, put a stop to all the organisation and work of the International Railway Congress Association. This body has now been revived in slightly different form under the style International Railway Association, with statutes practically the same as those of the former body. The association includes at present all the principal European, Asiatic and American countries, except Russia and the Central Empires. The General Secretary is M. L. Weissenbruch, 11, Rue de Louvain, Brussels. Copies of the English Edition may be obtained from Messrs. P. S. King and Son, Great Smith Street, Westminster, S.W.

LOCOMOTIVE SPECIFICATIONS.—A catalogue issued by the American Locomotive Sales Corporation, whose London offices are 26, Victoria-street, Westminster, gives a large number of illustrations of and tabular data concerning locomotives of all types built by the American Locomotive Company and Montreal Locomotive Works, Limited. The locomotives dealt with include all types, a very large proportion being for foreign railways. The book closes with specifications for workmanship and inspection which are very interesting, having regard to the development of the American export trade. It will be seen that the specifications for workmanship require the best practice, and there need be no fear that locomotives purchased from firms working to such shop regulations will fail to stand up to their work. The specifications go into details of boiler work, limits for working parts, pressures for wheels, bushes, &c., case-hardening and so on.

HANDLEY-PAGE AIR SERVICES.—We understand that from the commencement of British commercial aviation on May 1 last to the end of the year, upwards of 4,000 passengers and 43,267 lb. of freight have been carried by Handley-Page aeroplanes, an aggregate distance of nearly 70,000 miles. Messrs. Handley Page, it will be remembered, maintain a service of passenger and freight-carrying aeroplanes between London and Paris and London and Brussels, and these services will be developed considerably in the near future. New air routes will be opened, and contracts which have been secured for the carriage of mails, passengers and freight will be commenced in the coming spring. The firm's converted bombing machines, which have so far been employed for the transport services, will be replaced by new machines specially designed for commercial work and capable of carrying 15 passengers or 2 tons of goods at a speed of 112 m.p.h. Every endeavour will be made to keep pace both at home and abroad with the State-aided activities in commercial aviation of France, Italy, America, Germany, and other countries.

THREE-CYLINDER 0-8-0 TYPE SUPERHEATER LO

CONSTRUCTED AT THE COMPANY'S DARLINGTON WORKS, TO THE DESIGN OF SIR VI

(For Description see Pag

Fig. 2.

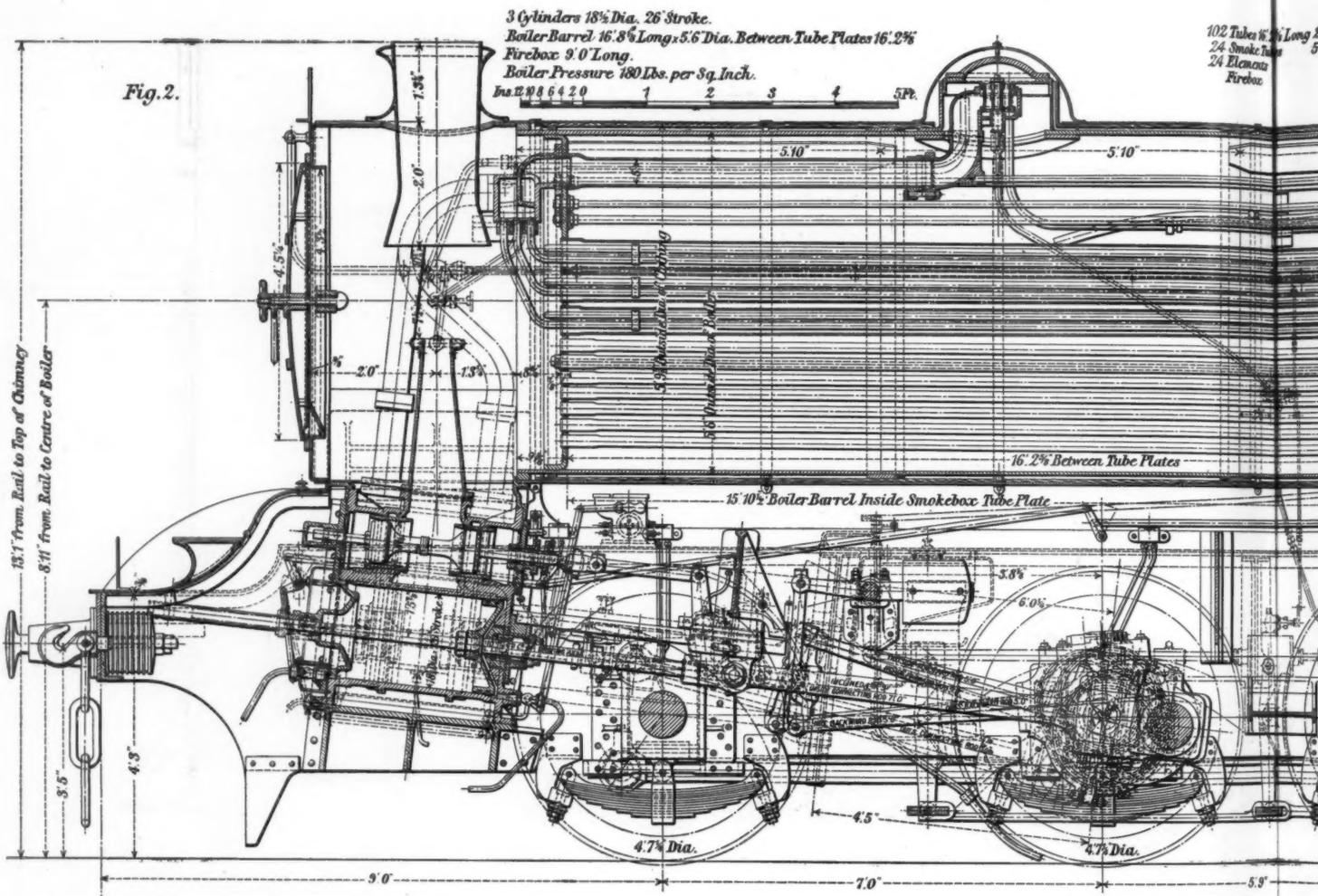
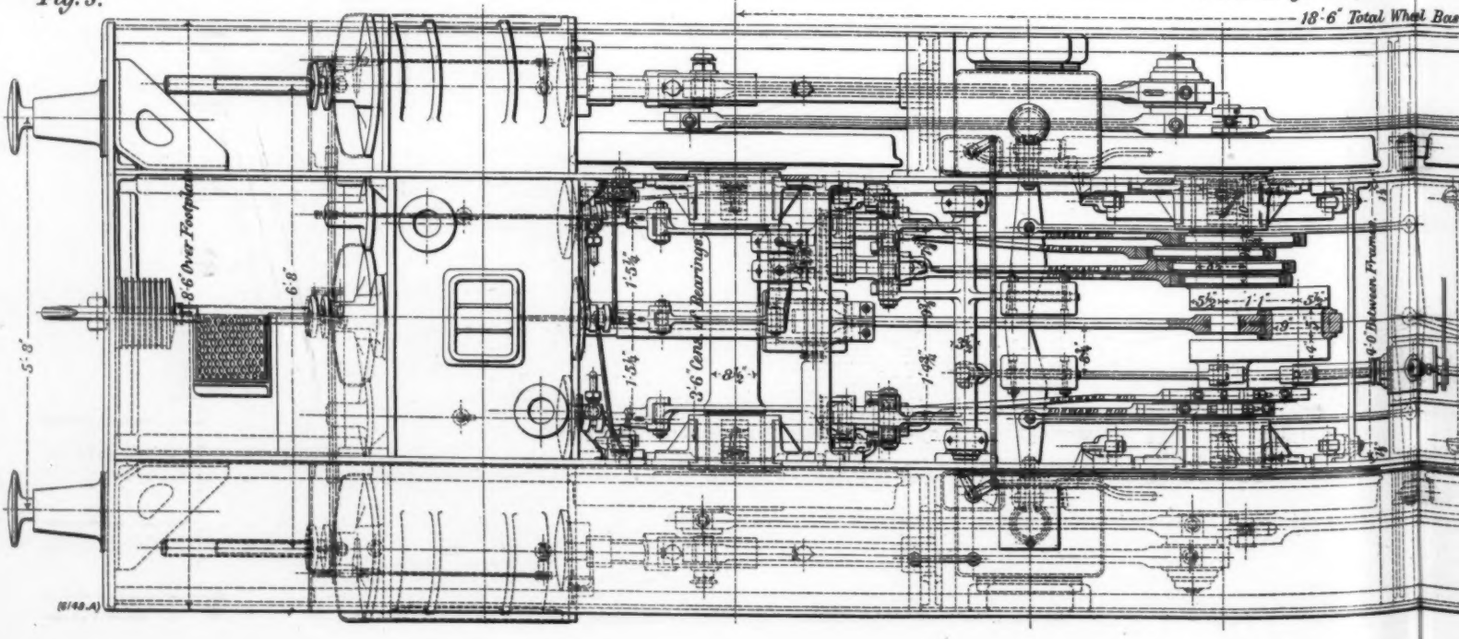

3 Cylinders 18½ Dia. 26" Stroke.
Boiler Barrel 16'.8⅝ Long x 5'.6 Dia. Between Tube Plates 16'.2⅝
Firebox 9'.0 Long.
Boiler Pressure 180 lbs. per Sq. Inch.
Ins 12 10 8 6 4 2 0 1 2 3 4 5Ft.
102 Tubes
24 Smoke
24 Elements
Firebox
13'.1" from Rail to Top of Chimney
8'.11" from Rail to Centre of Boiler
5'.10"
5'.10"
5'.8" Inside Barrel Ring
16'.2⅝ Between Tube Plates
15'.10½ Boiler Barrel Inside Smokebox Tube Plate
4'.7⅛ Dia.
4'.7⅛ Dia.
9'.0"
7'.0"
35'.6" Total Length of Frame
18'.6" Total Wheel Base

Fig. 3.



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TER LOCOMOTIVE; NORTH-EASTERN RAILWAY.

IGN OF SIR VINCENT L. RAVEN, K.B.E., M. INST. C.E., CHIEF MECHANICAL ENGINEER.

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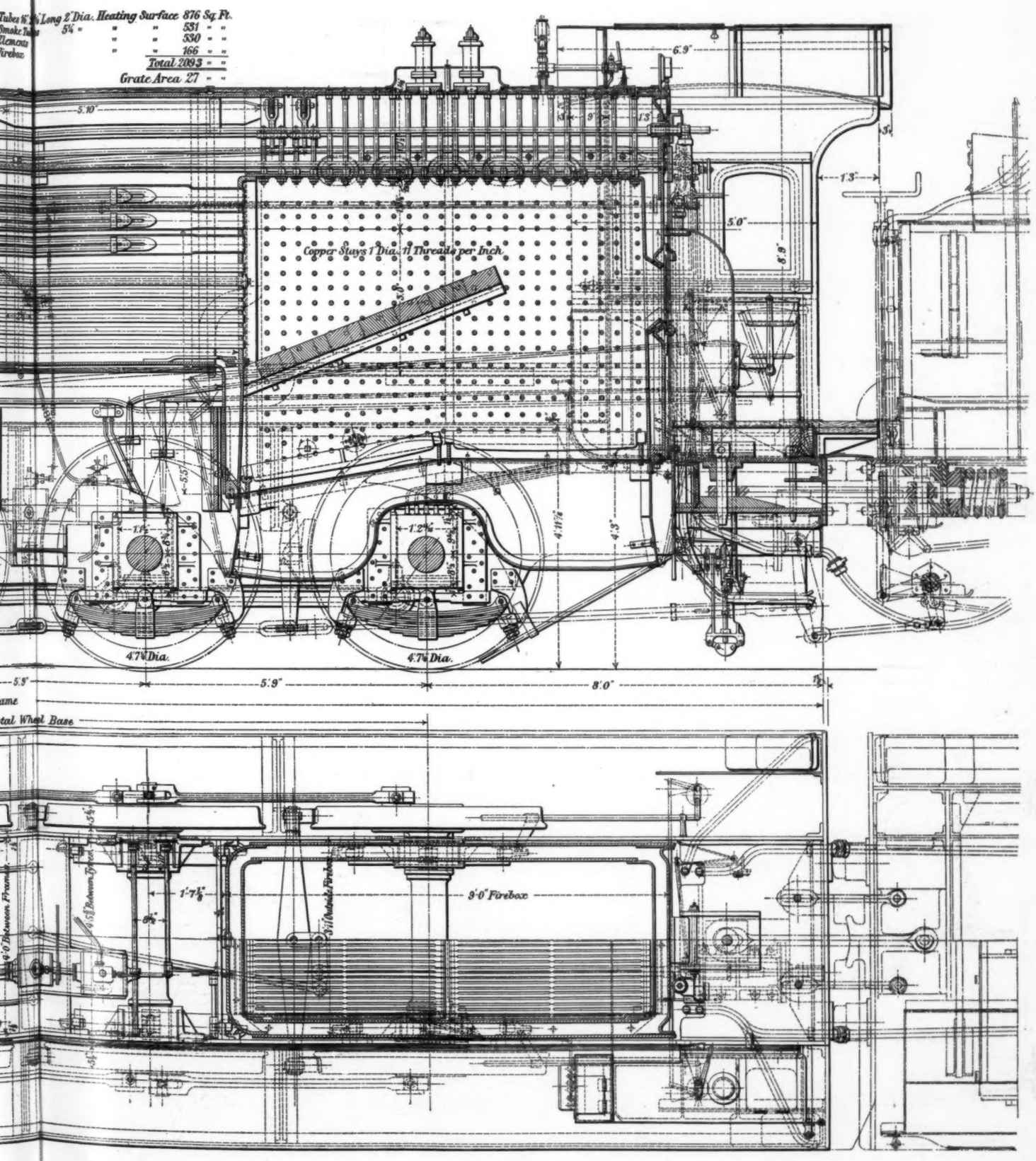

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ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

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NOTICE.

Owing to the enormous increases in the cost of paper, engravings, and printing charges generally, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 9d. to 1s. per copy. This increase dates from and includes the issue of Friday, January 2, 1920. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 49.

ENGINEERING.

FRIDAY, JANUARY 9, 1920.

WAGES AND THE COST OF LIVING.

WE remember, some year or two before the war, a well-known chief locomotive engineer of one of our railways saying that, as time went on, he continually found himself less able to concentrate on the technical matters which were properly his business, owing to the continually growing attention which labour matters demanded. It is to be feared that this engineer will not have found much relief in the year which has just closed. In our somewhat different sphere we feel in a similar way the increasing interference of labour questions with every branch of engineering. We have for very many years dealt in these columns with such labour matters as affect the engineering profession, but during recent months hardly a week has passed without some important labour movement or some decision affecting labour, requiring special discussion. From our particular point of view this matter in itself is of no importance, but from the more general standpoint of the prosperity of the industry and of the country it is to be hoped that some of the recent "settlements" may prove to be really settlements, and that some part of the valuable brains of the engineering industry, which has too long had to be occupied with labour, will be freed for its more proper function.

From this point of view the auspices of the latest important labour proposal are not too promising. During the week the wages offer of the Ministry of Transport to the railwaymen has been published. The general terms of the offer will be familiar to our readers. Each man now receives a war wage, additional to his pre-war wage, of 33s. a week. To this is to be added at once a further 5s. The total wage so formed is to endure until September of this year, and after that time an adjustment is to be made, up or down, in terms of the cost of living as defined by the figures published by the Ministry of Labour. The rise or fall of wages is to be at the rate of 1s. a week for a rise or fall of five points in the cost of living figures. Further than this, however, a minimum wage is established below which wages are not to fall, no matter to what greater corresponding extent the cost of living may decrease.

Whether this offer will ultimately be accepted or not it is impossible to say. The position at the time of our writing is that meetings at many important railway centres have proposed its rejection and that the matter is still under consideration by the executive of the National Union of Railwaymen. The situation has not been simplified by Mr. Bromley's speech on Sunday last, in which he outlined further demands from the locomotive men. It will be remembered that one of the claims of the National Union of Railwaymen was that they should be treated similarly to the locomotive men. The present offer is intended to meet that claim, but if one result of its acceptance is to be that the Associated Society of Locomotive Engineers and Firemen claim more, one will simply have the door opening on a still further claim from the N.U.R. The opposition of certain branches of the National Union of Railwaymen to the present offer appears, in the main, to be based on the fact that the proposed minimum wage is determined as one showing a 100 per cent. increase on the average pre-war wage in the various grades. The branches claim it should be based on a 100 per cent. increase on the maximum pre-war wage. Mr. Bromley's further claim for the locomotive men arises from the fact that when their advance was given the cost of living had increased 117 per cent. over the pre-war cost. The figure has now reached 134 per cent. over the pre-war level, and it is claimed that the locomotive men's award requires modification accordingly.

There would probably be little use in discussing the current offer in detail at the moment. The present state of affairs necessarily suggests further conferences and possibly a modified offer, and for the moment the question of the actual wages at issue may be left to develop. There is one aspect of the offer, however, which may well be discussed and which demands discussion. This is the proposed introduction into normal trade relations of a sliding scale of wages operating in terms of the cost of living. This principle as an artificially-controlled element was introduced into industry by the Government during the war. By artificially-controlled we mean that wages in certain industries were directly regulated by Government decree in terms of the rising cost of living. There was no such definite sliding scale as is now proposed for the railwaymen, but the principal of such artificial control was introduced and recognised. We emphasise the matter of artificial control, since in the long run wages have always been fixed in terms of the cost of living. The process has been a natural one, and has perhaps operated slowly, but in any healthy industry a rise in the cost of living has been followed by a rise in wages.

The new spirit which has certainly to a very considerable extent permeated the community, at least of this country, may ask why an old halting natural method by means of which wages followed prices should not be replaced by a scientific tabulated method in which wages will directly follow prices in terms of a pre-arranged schedule and at pre-arranged brief intervals. For not only the new spirit, but the plain man can very clearly see that if this principle is introduced into the relations between railway servants and the railway companies, there is no reason why it should not be introduced into every walk of life. And both can see that if it is so introduced, such extension to trades generally will very quickly follow.

One does not wish, without good cause, to oppose a new spirit, so many of the attributes of which are admirable, but this sliding scale of wages in terms of the cost of living carries so much danger that we cannot pass its official introduction in normal times without protest. No doubt in the new age, of the solvency of which Mr. Sidney Webb is quite satisfied, and when everything is to be run by the State, it will be feasible artificially to regulate wages in terms of prices, but at the present time we are far from the new age and our solvency is a matter of much concern. It is as well occasionally to remember that this country is now paying its way, or attempting to pay its way, entirely as a result of the efforts of private industry. The various great services which the Government either control or are seriously interfering with, are paying nothing, or less than nothing, towards the carrying-on of the country. The plain man in many of his manifestations is so tired of civil service methods in industry and looks upon Government control as so inefficient that he might care little if a sliding scale of wages in terms of prices were introduced into all Government services. The danger is, however, not that Government services will become more efficient, but that the principle which is at first sight an attractive one will by degrees spread to all industry.

We have permitted ourselves this digression in the direction of civil service control of industries since it helps to accentuate the importance of private industry and the danger of the new principle we are discussing. Private industry is now doing

all the work and will continue to do all the work and it is only upon private industry that the solvency of the State rests. This being so, it is clearly undesirable to introduce a principle which may seriously hamper private industry as an artificial regulation of wages in terms of the cost of living certainly would. The danger of the thing is surely obvious. With their opposition to piece-work and premium bonus systems the working classes seem to feel little enough incentive now to increase their output—and consequently their wages. If, in addition to this, the natural incentive which results in slack work leading to high prices is to be cut out, private industry receives one more handicap in its very gallant attempt to carry on.

Increased production has been preached by every colour of politician and every class of business man, and the basis of their preaching has been sound. Everything depends on increased production. This being so, why remove one of the main incentives which the working man now has towards that increased production. We are aware that what we are saying may be used as an argument against high wages, and if it is used only against high wages which are not earned, it may be very justly so used. In the position to which labour has now attained in this country there is no fear, however, of starvation wages being either offered or accepted. Labour is quite well able to look after itself. This is no reason, however, for the introduction of a principle which labour on a large scale has certainly never asked for, and which is economically unsound.

What is the present position? Greater production is wanted, is indeed vital. Many branches of labour refuse to agree to piece-work or similar systems in which the harder worker is directly rewarded. As a small substitute for an artificial system of reward for harder work, we at least have the spur of rising costs to help the workman to a greater output. This benefits both him and the State. The matter in practice fairly rapidly adjusts itself by a following rise of wages, but there is an interval in which more work is actually done than would otherwise be carried out. This, however, is not the main point. The chief question is one of moral effect. The workman has no grievance now more than any of us have. He must take the world as he finds it and do the best he can for himself. This latter he has recently managed to do very effectively. None the less a rising cost of living is some spur to do a little better than he did before. Cut out all effect of rising prices, and what has the workman to care for? As long as he keeps his job it is nothing to him if prices double again. His wages also automatically double, and he is where he was with no effort of his own. This would be a most unsound condition, both from the point of view of the workman and of the country. The country would lose in output, and the workman would lose in initiative. A strike is not a desirable social phenomenon, but it is enormously better that a workman should have to make an effort if he wishes to raise his wages, even if the effort takes the form of striking, than that he should simply have to do nothing at all and that with a rise in prices with no effort or thought from him his wage would rise as the sun rises on each new day.

THE SUCCESS OF THE SHIPPING CONTROL DEPARTMENT.

ON the immediate fighting front no class of the community can claim to have excelled the others in devotion and self-sacrifice. At home, unfortunately, a different condition of affairs obtained, and some branches of organised labour, at any rate, took the opportunity to exploit the national extremity for their private benefit and profiteered without compunction. Again "dilution" was strongly resented and only admitted under the most stringent conditions, and finally we see now that certain Unions are strenuously opposing the entrance into their particular trades of a small percentage of ex-soldiers who in many cases spent in defending those who now reject them, the years they would in normal course have devoted to learning a trade. In striking contrast with this behaviour has been that of the employers. When skilled chemists were wanted for our explosive factories and for chemical warfare work, one of our largest and most progressive firms offered the pick of their staff without restriction, while so far from torpedo-boat and destroyer builders resenting the "dilution" due to the placing of orders, with yards previously only engaged on commercial work, they gave the new beginners every assistance in their power, putting at their disposal the whole of their dearly-bought and highly valuable experience.

The fifth report of the Select Committee on National Expenditure just issued, notes repeated instances of similar high-mindedness on the part of prominent men in the shipping and shipbuilding trades. The technical and commercial sides of the Ministry were managed almost entirely by men of wide experience and technical knowledge obtained from outside firms. Many of them, it is stated, served without salary or remuneration, and the Committee reports that "it would have been impossible to carry out the business of the Ministry in the very efficient way in which it has been done without the expert knowledge and patriotic devotion" of these recruits. The Ministry of Shipping has come in for a good deal of criticism both during the war and since the armistice, the accusations ranging from extravagance in personnel to incompetence in providing and running the ships. The report states, however, that in the opinion of the Committee the staff employed was not excessive. The number at headquarters attained its maximum in November, 1918, when the total was 1,763, of which 940 were women. About 2,000 persons were employed elsewhere at British and foreign ports. A number of highly complicated accounts still require adjustments so that there can be no reduction in the financial branch for some time to come.

Referring to the work done by the Ministry, the report states that when losses by German piracy reached its maximum of 590,000 tons in April, 1917, the Ministry requisitioned practically the whole of British sea-going tonnage exclusive of vessels of 300 tons and under. Ships were purchased abroad wherever available, and at prices corresponding to the urgency of the condition. The prices ranged from 45*l.* 7*s.* 10*d.* per ton for those built in the United States to 33*l.* 1*s.* 9*d.* per ton for vessels built at Hongkong. The price paid for the 19 vessels built in Japan was 44*l.* 17*s.* 8*d.* per ton. Canada supplied 44 at 39*l.* 10*s.* per ton, in addition to 16 wooden steamers which cost 42*l.* per ton, but are now worth much less. The value of steel vessels has, on the other hand, been maintained.

The ships taken over by the Government were either fully requisitioned or operated under the Liner agreement. Under this scheme the vessels of the companies running on regular routes were worked for the Government by the companies, and it is pleasing to note that the Committee are able to report that under this scheme the companies worked as efficiently as if they had been trading on their own account. The Government assumed the war risks for the ships they controlled, and have paid out on account of losses 107,730,000*l.* The outstanding claims are said to be inconsiderable. The "Blue Book" rates were settled by a Transport Arbitration Board, and in some cases were reduced as the result of experience. In other cases it was found necessary to increase them on account of the large increase in working expenses, and in particular of the rise in the insurance premiums (for ordinary marine risks) due to the enormous increase in the cost of replacing a lost vessel. Ultimately the hire rates paid were 29*s.* per ton per month for vessels of from 301 to 450 tons register. This rate diminished with the size of the vessel, being 13*s.* per ton per month for ships of over 7,000 tons deadweight capacity. In the case of liners a premium was paid for speed.

Much more had, of necessity, to be paid for neutral tonnage when hired or requisitioned. The report makes the following comparison:—Taking a "tramp" steamer of over 6,000 tons deadweight, then when the rate paid to a British owner was 8*s.* per dead ton per month, a Greek ship received 30*s.*, a Swedish or Norwegian 41*s.* 6*d.*, a Danish ship 45*s.*, and a Dutch ship 41*s.* 6*d.* per ton per month. The fact that facilities for bunker coal were at the command of the British Government was a factor in fixing the rate at which neutral tonnage could be obtained. At the date of the armistice about 2,800 British ships of over 1,600 tons were under requisition and, with the substantial exception of those required for naval or military needs, these ships have since March last been released on their first return to a port of the United Kingdom. Enemy prizes and neutral vessels requisitioned during the war were managed by Messrs. Furness, Withy and Co., who made no charge for their valuable services.

To replace losses as rapidly as possible it was necessary to develop further the shipbuilding facilities of the country. To this end the Government gave 1,900,000*l.* as free grants in aid to meet the expenditure undertaken by shipbuilders in extending their yards. The Committee report that this procedure was fully justified as the costs of all building and new machinery were, at the time, prohibitive as a commercial investment. In all cases the shipbuilder, to get assistance, had himself to make a very substantial expenditure, the contribution from the Government averaging about 36 per cent. of the total. The policy of building standard ships resulted, it is stated, in a great acceleration in the rate of construction, and facilitated the supply of material, equipment and machinery. The Committee report that the shipbuilders gave all possible assistance and readily placed the whole of their resources at the disposal of the Ministry.

Unhappily, they are unable to give a similar testimonial to ship repairers, either masters or men. The former were said in some cases to be "very independent and did not render the Ministry the same assistance as was obtained from the shipbuilders." As for the men at London and Southampton they refused to undertake piece-work, with the result that vitally important repairs at these ports were "comparatively slow and costly."

The Committee also discuss the national slip-yard fiasco, but devote to it only a few paragraphs of their report. The total expenditure on these yards is placed at 6,120,000*l.* Had the scheme been completed there would have been 36 slips in the three yards at Chepstow, Beachley and Portbury, with an output of 1½ ships per week of 10,500 tons each. This would have been a valuable contribution to the construction of the 3,100,000 tons of merchant shipping per annum which was the output aimed at during the later period of the war. The ships were to have been of the "fabricated" type. Of these 42 were ordered of the N type and 11 of the N1 type. Of the former six only are being proceeded with, whilst of the latter eight have been built and sold, making a total of 14 either built or building in the National yards. In addition, five are being built elsewhere. It is stated that the type is not so suitable as standard ships under ordinary circumstances, and that the expectation of being able to construct these vessels with a small proportion of skilled labour has not been realised. The cost of a 10,500-ton fabricated ship is said to be 198,000*l.* The Committee report that great confusion was revealed in the accounts relating to these yards, for which no adequate excuse was forthcoming. As matters stand the assets should, they state, be realised and the loss cut. Negotiations are in progress for the sale of the Chepstow yard, but no applicants have yet appeared for the sites at Portbury and Beachley. It will be remembered that the Government offered to transfer these yards to certain Trade Unions on very liberal terms but the offer was declined.

THE PANAMA CANAL.

THE Panama Canal report for the year ending June 30, 1919, gives a *resumé* of canal operations for a complete twelvemonth, during which the use of the canal was not interfered with by slides or other serious accidents. The use made of the canal in this twelvemonth cannot be regarded as indicative of its ultimate value as a trade route, on account of the period being an abnormal one, including as it did a portion of the year during which hostilities were still being carried on, and terminating too soon after the armistice for normal

conditions to be resumed. Normal conditions embracing the canal route will only commence when the repatriation of all colonial troops has been completed, and the trade of the world has settled down again to lines demanded by the peaceful evolution of civilisation.

The figures given for lockages at the three points, Gatun, Pedro Miguel and Miraflores, vary slightly, presumably either due to the length of time involved in working through the canal resulting in some vessels having passed some of the locks before the period commenced, or to the fact that vessels which had passed through some of the locks singly passed other locks with other vessels in the same lockage. If we take the Pedro Miguel lockages it is found that of the total of 2,444 operations, some 2,019 were for commercial vessels and 117 for the purposes of the United States Navy and Army, while canal equipment passing to and fro' was responsible for 308. The movements necessitated by vessels for the Navy and Army were much heavier than at any previous time, as might have been expected under the international conditions then prevailing. The commercial vessels and launches worked through numbered 2,045, in 2,019 lockages, showing that in several cases two or more of the smaller craft went through locks together. The same occurred with non-commercial shipping. The lockages number about seven a day at present.

It has always been a matter of interest as to whether the water supply of the catchment area available would prove suitable to the high level canal project. In this connection the report gives some very interesting figures. It may be noted in passing that the announcement has just been made, that on account of a short rain supply in November the lake level has been raised to the 87-ft. level earlier than usual, in anticipation of an abnormal dry season. The normal level is 85ft., but it is raised to 87 ft. usually in the middle of December in order to secure reserve. The total amount of water passing off the useful catchment area per month averaged about 15,410,000,000 cub. ft. Of this amount, 35·24 per cent. was put to use, but only 9·232 per cent. was used for lockages. Of the water lost, 8,094,000,000 cub. ft. went over the Gatun spillway and 12 per cent., or 1,807,000,000 cub. ft. were lost by evaporation. Leakage at the locks and spillway amounted to about 44,000,000 cub. ft. Of the water used 3,611,000,000 cub. ft. was the average for the amount taken by the hydro-electric plant at Gatun. The lockages absorbed 1,423,000,000 cub. ft. The electric plant took 66·5 per cent. of the water usefully employed, or about 20 per cent. of the yield of the watershed.

The yield is uncertain and the year under review was below normal as regards rainfall, to the extent even of 39·59 in. at Bohio. The first three months of 1919 proved the lowest on record, but the dry season ended slightly earlier than usual. Evaporation was naturally high, and above all previous records. The discharge of the Chagres River into the Gatun Lake varied from a maximum of 61,200 cub. ft. to 446 cub. ft. per second. The result of this large range is seen in the high figure for the spillway discharge which is about 59 per cent. of the total amount of water available. At the end of the dry season the elevation of the lake had been reduced from practically 87 ft., to 83·7.

The electric towing system at the locks met with two accidents during the year; both seem to have been due to a fault in design capable of being, and since, remedied. Both accidents happened to the same locomotive. In each case getting out of control it ran down one of the inclines. These locomotives are not under control when the clutch lever is in the neutral position. As an expedient a bell has now been fitted which continues ringing so long as both clutch levers are out of either the 2-m.p.h. or 5-m.p.h. notches, at both ends of the machine. A new brake is also being fitted which will operate regardless of the clutch levers—a very necessary precaution under the circumstances. It is recorded that the wooden fender cribs at Miraflores and Pedro Miguel locks have been so destroyed by teredo that they have had to be renewed.

The actual lockage operations suffered a small delay of about 5 hours on one occasion, owing to the accidental flooding of the transformer rooms in the lock walls at Miraflores. The accident was due to the operator opening one set of valves under the impression that another set had previously been closed. From this it would appear that the interlocking of the controls is not quite so complete as it should be, or as the claims once made for it. In connection with the maintenance of the lock machinery the report states that a good many of the roller trains of the rising stem valves have become badly worn. The rollers themselves have worn down and the holes in the channels in which they are carried are also badly enlarged; the tracks also have suffered and will need renewal in many cases. The seals have had to be replaced, and in many cases new materials are being tried. The leather seals of the cylindrical valves having become hard and brittle, were being replaced by rubber.

During the year the Gatun hydro-electric plant was increased by a 4,500-kw. unit, bringing the capacity of the station up to 13,500 kw. A further unit is being proceeded with. The plant now installed is able to take peak loads without the assistance of the steam-generating sets at Miraflores. The latter plant is therefore an emergency stand-by. Steam is kept in the boilers by small oil fires ready to start the plant up at a moment's notice. The plant is started automatically on failure of the Gatun supply. Failures in the 44,000-volt transmission line across the isthmus have been greatly reduced by the introduction of additional units to the insulators. These failures numbered 17 in 1917, 29 in 1918, while from July, 1918, to February, 1919, no less than 32 occurred. After the new insulation was effected in February, down till the end of June of last year, no failures had been reported.

Work was continued on six of the 16 slides under observation in the Gaillard or Culebra Cut. The greatest quantity taken from any particular slides in the twelvemonth was 414,200 cub. yards. This came from the so-called New Culebra Slides, and 315,000 cub. yards were rock. Altogether 23,822,000 cub. yards have been removed from these slides. It is estimated that another 1,000,000 yards have yet to be removed. Only some 34,000 cub. yards were taken out of the Cucaracha slide, making a total from it of nearly 6,000,000 cub. yards. The total excavated to date of the report from the whole cut, amounted to 35,187,417 cub. yards. This is equivalent to more than one-third of the whole excavation originally anticipated for the high-level scheme, showing how greatly the instability of the ground has added to the work of construction.

In conclusion, we may briefly refer to the sanitation report. Although yellow fever has ceased to be a serious menace, and the malarial rate has been reduced to moderate limits, we no longer hear the Canal Zone boosted as a health resort. With pardonable pride at what had been effected, the characteristic proneness of the people of the United States to adopt picturesque rather than strictly accurate, language led a few years ago to rather too glowing accounts of the efficacy of the freedom of the Isthmus from sickness. This, we take it, was partly intentional in connection with the recruiting of staff and labour. It is now decided, however, that prolonged residence on the Isthmus is prejudicial to health, and two months annual leave is recommended with increased pay to permit of advantage being taken of it. Investigations with regard to the prevalence of *anopheles* continue, and have shown that both *anopheles albimanus* and *an. tarsimaculata* travel a good deal further than was originally suspected. Invasion has been traced to points over a mile distant, so that drainage, &c., will be carried in future further afield in all possible neighbourhoods. A great deal of care is also exercised in keeping cattle at a safe distance from all regular residential districts as the mosquitos are found to breed in the wet hoof marks. As the cattle industry is becoming an important one on the Isthmus caution in this direction will not be misplaced.

THE NEW PATENTS ACT.

On previous occasions we have made reference to the proposals for the reform of our Patent Law, which have been occupying the attention of Parliament during the session just closed and have raised great interest in industrial circles in this country and abroad. The proposals received the Royal assent on December 23 last, and are now part of the law of the land. The new Act is in force, except Section 1 and certain parts of Section 2, which are to come into operation at a date to be decided by the Board of Trade.

The new Act makes numerous alterations and amendments to the Act of 1917, and as many of these are vital to the interests of patentees it is necessary for the latter to make themselves acquainted with the changes of the law which will considerably affect their positions. We do not intend in the present article to criticise the new features of the Act (time will show whether the changes made are good or bad), but merely to point out in what way the law has been altered.

The period of Provisional Protection has been increased from six to nine months, and as a consequence the time within which the complete specification must be accepted has also been extended for a period of three months. The new Act is said, in Section 21 (1) to apply to "applications . . . made before . . . the passing of the Act." Apparently, therefore, any application accompanied by a provisional specification and lodged subsequent to March, 1919, may be completed within nine months of the date of application, or by the payment of a fine, within ten months. Inventors who have allowed their applications to lapse not more than four months ago are thus afforded an opportunity of reviving them. The duration of the patent term has also been extended and the life of a patent is now sixteen years. The new Act prescribes that this extension applies to all patents on applications dated December 23, 1905, or later, and not allowed to become void before the commencement of the Act. Renewal fees will be payable in respect of the fifteenth and sixteenth years, but the amount of the fees has not yet been announced.

During the passage of the Bill through the House of Commons attempts were made to include an amendment by which patentees who had suffered loss or damage by reason of the recent hostilities were to be recouped by an extension of their patent terms. This amendment was rejected by the Government, but in the House of Lords, as a result of further and greater pressure, the Government accepted an amendment by which a patentee who has suffered loss or damage (including loss of opportunity of dealing with, or developing, his invention owing to his having been engaged in work of national importance connected with the war) may apply, in a more simple and cheaper manner than was before possible, for a prolongation of the term of his patent, and the Court in considering the application may have regard solely to such loss or damage. The mode of application to be adopted by a patentee who desires a prolongation of his patent term by reason of the circumstances stated, is by way of originating summons, instead of by petition, and if the Courts deal sympathetically with such applications the enactment will go a long way towards recompensing patentees for the damages they have sustained and for the period of their monopoly they have lost.

The ground of opposition to the grant of a patent has been extended to include prior publications other than patent specifications. It will now be possible to oppose an application on the ground that the invention has been published in, say, a newspaper or technical periodical issued prior to the date of application. The amending section does not extend the official search as to novelty and permit the examiner to cite publications other than British specifications to which the official search is restricted. Prior to the Act we are now considering, the results of the official examination as to novelty were secret, but now the Comptroller may, on application in the prescribed manner, disclose the result of the examiner's search.

An inventor will not now prejudice his rights to apply for and obtain a patent in respect of his invention if he reads a paper containing a description thereof before a learned society and has, before such reading, given notice of his intention so to do. The inventor, however, must apply for a patent within six months of the reading or publication of the paper. This new provision in the law contains

a beautiful pitfall for patentees and advantage should not be taken of it without professional advice, as its employment is fraught with the greatest danger.

The specifications of inventions relating to substances prepared or produced by chemical processes are not to be allowed to include claims for the substance itself, except when prepared or produced by the special methods or processes of manufacture described and claimed or by their obvious chemical equivalents. This enactment only, however, applies to patents applied for after the passing of the Act.

A large part of the new law is devoted to the substitution of new sections for Sections 24 and 27, in the 1907 Act. Sections 24 and 27 both deal with the reduction of a patented invention to practice within the United Kingdom. Section 27 of the 1907 Act dealt with the revocation of a patent which was not worked mainly or exclusively in the United Kingdom. The purpose of the new section is to prevent in a general way an abuse of the monopoly rights. For determining whether there has been any abuse, it shall, according to the new Act, be taken that patents are granted not only to encourage invention, but to secure that new inventions shall, as far as possible, be worked on a commercial scale without undue delay. A definition of the term "working on a commercial scale" is contained in the Act, and means the manufacture of the article or the carrying out of the process described and claimed in the specification of a patent in, or by means of, a definite and substantial establishment or organisation, and on a scale which is adequate and reasonable under all the circumstances. Five conditions are enumerated in the Act as constituting an abuse of the monopoly rights and the Comptroller has five ways of dealing with a proved case of abuse.

Section 24 of the 1907 Act provided that anybody interested may present a petition for a compulsory licence to the Board of Trade. According to the new Act, a patentee may at any time after the sealing of his patent, request that the patent be endorsed with the words "Licences of right." This section therefore differs, for instance, from the Canadian compulsory licence provision in failing to limit the time at which a compulsory licence must be applied for, and it differs from the old Section 24 by granting this right to the patentee himself. When a patent is so endorsed the patentee must grant a licence either by agreement or in default of agreement as prescribed by the Comptroller. The section contains provisions to guide the Comptroller with the intention of securing the widest possible user of the invention, with a reasonable advantage to the patentee. Patents which are subject to licences of right, are only subject to renewal fees or taxes amounting to one-half of those that would otherwise be payable.

Finally, the Act, in addition to many minor amendments, contains a section under which it is forbidden for any person to practice, describe or hold himself out, or permit himself to be described as, or held out as, a Patent Agent, unless he is registered as a Patent Agent, and the expression "Patent Agent" is defined as meaning a person who carries on for gain in the United Kingdom the business of applying for, or obtaining, patents in the United Kingdom or elsewhere.

NOTES.

Patents and the War.

Patent applications lodged in this country take place at a surprisingly regular rate, if circumstances are normal, but change very quickly on the occurrence of large industrial alterations. Thus, at the beginning of the war a very marked variation was noted, the applications made prior to that date in the year 1914 being lodged at a uniform rate. A graphical representation showing the relationship between the time of the year and the number of applications lodged for the years 1913 and 1914, together with some statements on the general position of patents at the time, is to be found in ENGINEERING, page 53, of the issue for January 8, 1915. The actual figures for the successive war years are as follows:—1913, 30,102; 1914, 24,847; 1915, 18,225; 1916, 18,686; 1917, 19,358; 1918, 21,933; 1919, 32,892. As was to be expected with the ending of the war, there came a change in the class of invention for which a patent was sought. Instead of war materials, present applications deal with such varied matters as reinforced concrete schemes, vehicles, domestic appliances, means for conserving heat, aircraft, and the production of chemicals, but curiously enough, there are still a number of applications being lodged relating to inventions which it would appear are only useful for war purposes. It is possible that during this year, the numbers of applications may be varied in view of the new British Patent Law with which we have dealt in another column. What will be the result of this, one cannot say at present.

The Entertainment Tax on Trade Exhibitions.

Our attention has been drawn to a claim raised by the Board of Customs and Excise for Entertainment Tax on the Cycle and Motor Cycle Show of last year. Whatever the actual literal interpretation of the Finance (New Duties) Act of 1916, we cannot believe that the taxation of post-war trade exhibitions was in contemplation when the Act was framed. A trade exhibition of the type in question is a very different thing indeed from an entertainment which is merely of the form of a luxury. It is quite right that the latter should pay the tax, and no serious objection is raised to such payment by the public. A trade exhibition is on quite a different footing. It is not an entertainment, and only in a remote sense can it be said to be connected at all with luxury or personal indulgence. It is purely utilitarian, with the object of fostering and improving the nation's business. It seems to us that exhibitions of this class should be exempt, and that some discretion should be exercised in the interpretation of the Act on these lines. We all recognise that a charge levied on our pleasures is, in these days, quite a reasonable form of contribution to the State, but we are against any tax on business, especially on lines of trade which every one is keen on getting well started again on a peace footing. The Royal Agricultural Society's Show is said to be exempt from this tax. It is difficult to see why this show, which after all is only a trade exhibition of another type, should be free, when the engineering trades are to be taxed. There is no doubt that these exhibitions do a great deal of good when properly managed, and are a great incentive to industry. It is to be hoped that the authorities, by whom they are approved, will not handicap these legitimate developments by putting difficulties in their path, and trying to embrace in one category industrial enterprise and frivolous pleasure-seeking.

Recent Investments of Capital in Industry.

The last six months of 1919 witnessed an unprecedented volume of investments in newly-registered companies. The total subscribed in that period is placed by Messrs. Jordan and Sons, Limited, Chancery Lane, W.C.2, in their summary of statistics, at nearly 260,000,000*l.* distributed among about six thousand new companies. A special feature of post-war finance is, of course, the enormous increase in the capital of individual companies. In 1913, the average was about 21,000*l.*; to-day it is 45,000*l.*, or more than double. These figures give one the proportion merely, but the trend of business is more clearly indicated by the fact that in 1913 there were only 21 companies with a capital of over 1,000,000*l.*, whereas in the last six months of 1919, no less than 48 concerns were registered with an aggregate capital of 90,000,000*l.*, the individual firms ranging up to six millions. The cause for this is to be found not only in the fact that trading in special lines on a larger scale is being adopted as a set-off to increased cost of production, but also to the greatly depreciated value of the 1*l.* sterling. It is interesting to note that shipping companies are responsible for about 8·3 per cent. of the capital raised in the past six months. This is the natural outcome of the shortage of shipping, and the boom which that trade is experiencing. There are now prospects that this will pass before long, and shipping will then cease to stand at its present extremely attractive level. Mines are responsible for not far short of 10 per cent. of the capital subscribed, and oil comes in for about 7·4 per cent. Both these are, or should be, sound sources of wealth. Textiles rank also very high (nearly 10 per cent.), due, doubtless, to the attractively high prices of finished goods now prevailing. On the other hand, the fact that engineering businesses have obtained about 5 per cent. of the subscribed capital, while half as much again has been subscribed to firms engaged in the motor industry, is not at all reassuring. The latter is partly, at least, a luxury trade, and it would be more satisfactory to see a greater proportion of the money going to the engineering trade, in order to build up a better position for the whole world, as regards necessaries of life. It is noticeable that the iron and brass trades absorbed about 4 per cent. only of the capital subscribed, while cinematograph shows took just about the same. Here, again, we have a very unsatisfactory feature. The chemical industry, which should be encouraged, if we are to secure a proper share of the world's trade, absorbed less than 2 per cent. of the capital subscribed. Altogether the money invested, while it may meet with pretty good returns, has not been, in many instances, put into industries which will help to re-establish our trade and ensure a sound commercial position for us among other nations.

The Earnings of Cargo Steamers.

Although the profits earned by shipping companies owning cargo steamers have been highly satisfactory during the past few years, the fact that a considerable number of experienced owners have disposed of their vessels seems to indicate that they anticipate a considerable decline in earning power in the near future. From some interesting statistics published by our contemporary, *Fairplay*, we gather that the average dividend paid by cargo boat companies for the eight years ended 1911 amounted to only 3·3 per cent., and, in this connection, it must be borne in mind that the amounts set aside for depreciation during that period were quite inadequate. Had proper allowances been made for renewals practically the whole earnings would have been absorbed. In the two clear years preceding the war, 1912 and 1913, a considerable improvement was made, the dividends amounting to 6·82 per cent. and 12·56 per cent., respectively, and the allowance for depreciation to about 7½ per cent. and 15½ per cent.; the depreciation, it should be noted, is calculated on the original cost of the steamers. For 1914 the dividend fell to 10·38 per cent., rising to 11·43 per cent. in the following year, and reaching the high figure of 18·5 per cent. in 1916. The record was reached in 1917, when an average dividend of 19·24 per cent. was paid, and since that time the dividends paid have fallen to a slightly lower level than those for the pre-war year 1913; the figures for 1918 and 1919 were 12·15 per cent. and 12·47 per cent., respectively. The allowance for depreciation amounted to 9·7 per cent. in 1914, and to 10·2 per cent. in 1915. In 1916 the figure reached was 17·3 per cent., while for the three following years the figures were 13 per cent., 4·3 per cent., and 5·85 per cent., respectively. With regard to future prospects of shipping companies it is estimated that, in the current year, some 12,000,000 tons deadweight of shipping will be built and placed upon the trade routes of the world, and it is not unreasonable to anticipate that this will have a considerable effect upon freight rates. In view of the present enormous cost of constructing new shipping, the action of those owners who have sold their fleets is not surprising, though it must be admitted that the purchasers are generally men of considerable business ability. Some interesting figures relating to the cost of construction during the last 20 years have been given by Messrs. C. W. Kellock and Co., of London and Liverpool. From these we gather that the cost of a complete new 7,500-ton cargo steamer was lowest in the middle of 1908, the figure at this time being 36,500*l.* Immediately before the outbreak of war the cost of a similar ship would have been about 42,500*l.* The cost had risen to 60,000*l.* by the end of 1914, and had more than doubled this figure by the end of the following year. By the end of 1916 the cost

had risen to 187,500*l.*, but declined somewhat after this time, the figures for the ends of 1917 and 1918 being 165,000*l.* and 169,000*l.*, respectively. In 1919 a further enormous rise in cost occurred, so that, in December last, a boat of the size abovementioned would have cost about 232,500*l.*, which is six or seven times the cost of a similar vessel in 1908. With these figures in mind, and also remembering the greatly increased cost of working, it is not difficult to imagine the effect of a reduction of freight rates in the future.

The Difficulties of Peace in German Shipyards.

The German shipyards found themselves in an awkward and difficult position at the termination of hostilities, as all war contracts automatically came to an end, and the firms have since encountered many troubles in connection with reconstruction. The conditions in the Peace Treaty appear to them to be somewhat vague and capable of divergent explanations, and even now they hardly know for whom they may build and who is to be the definitive owner of the vessels they do build. The revolution also brought serious labour troubles which only increased as the time went on; the men kept asking for higher and higher wages, and at last their demands rose to such a height, that a lock-out appeared unavoidable. Even if the labour trouble should be removed, there is an embarrassing shortage of raw materials, especially steel and coal. The monthly consumption of steel in the German shipyards amounts to about 50,000 tons, but the obtainable quantity has now receded to 7,000 tons per month, or only 14 per cent. of what is required. Under these circumstances it is really of less importance, that orders are only coming in sparingly, and that no contracts are being placed for ships of more than 1,200 tons. As the large shipyards are constructed with the view of building much larger vessels, these orders for comparatively small vessels do not count for much, and they also generally go to some of the smaller yards. A visit to Hamburg will reveal the actual state of affairs. There is practically no work going on. The dry docks and the floating docks are empty, and the cranes idle. In order to find some employment several yards have taken to fresh kinds of work, for instance, repair of locomotives, railway wagons and such like. The Danzig shipyards have had to stop shipbuilding in the meantime for lack of raw materials, and have gone in for the building of locomotives, as has also the Schichau yard. The number of hands employed at the German yards has, in consequence of all this, dwindled down to about one-third, 75,000 employés against 200,000 rather more than a year ago, and men are being discharged every day. The handing over to the Entente of the 400,000 tons of floating docks, &c., will, it is contended, mean a state next to stagnation within the German shipbuilding industry. Professor Haas's prophecy, that Germany could rebuild her lost fleet within six years is bound to prove very wide of the mark. Piece-work pay has been resumed at one or two of the Hamburg shipyards; the German shipyard at Finkenwerder, which is closely allied with the Hamburg-America Company was the first to make the move, and the Blohm & Voss yard decided to follow the example, two-thirds of the men voting in favour of the system.

Mineral Wealth of the Empire.

Sir Richard Redmayne has given some very interesting information concerning the Imperial Mineral Resources Bureau. He stated that at the Imperial War Conference held in 1917 it was agreed to set up such a Bureau, for collecting information from the appropriate departments of the Governments concerned and from other sources regarding the mineral resources and metal requirements of the Empire, and for advising what action, if any, might be desirable to enable such resources to be developed and made available to meet requirements. The composition of the Bureau was completed at the end of July, 1918; the governors number 14: there are five Dominion representatives, one for India, one nominated by the Secretary for the Colonies, and six members, eminent in mining and metallurgy, appointed by the Lord President of the Council. Earl Curzon, who occupied that office during the formation of the Bureau, is its president. Sir Richard Redmayne is chairman, and represents the United Kingdom on the Board. There are four standing committees of the governors, dealing respectively with intelligence and publications, research and developments, general purposes and finance, and legal matters. The offices are at 2, Queen Anne's Gate Buildings, Westminster, where an expert and secretarial staff is constantly at work. The cost of running the Bureau is met out of an allowance of 10,000*l.* per annum contributed by the British Government, and by contributions from the Dominion Governments and India, which it is expected will amount to another 10,000*l.* per annum. Sir Richard stated than an immense amount of valuable work is being done throughout the Empire to obtain information; much of this, however, has been practically inaccessible hitherto in quarters where it was most needed. The need for the Bureau is all the more pressing owing to the wide geographical distribution of the Empire and the distances separating its component parts. The development of the Empire's mineral resources has so far lacked co-ordination and control. This will soon be a matter of the past, for the Bureau will foster and safeguard these resources and promote the welfare of related industries. It is engaged on an extensive system of classification of the Empire's mineral wealth, and is on the eve of publishing a digest of statistical and general information relative thereto. It has framed suggestions for a uniform system throughout the Empire of collecting and publishing intelligence regarding minerals. While watching and encouraging research and carrying out investigations with the object of improving current processes and introducing new ones, the Bureau, generally speaking, does not itself engage in the work of research and development, though it has the power to do so should it be deemed advisable. In regard to intelligence and publications, research and developments, 16 committees have been set up who have mapped out an extensive field of work, the accomplishment of which will be far-reaching. The object of these committees is the closer linking up of the Bureau with the respective mineral and metal industries of the Empire. The Bureau is also now engaging in the formation of an index of technical information and the establishment of a working library; it is already daily employed in supplying information to many enquirers. It is confidentally anticipated, in the words of Sir Richard, that within a very short time the Bureau will have been the means of so developing the mineral resources of the Empire, that the Dominions, as well as the Mother Country, will not fail to realise that the cost of running it is but a drop in the bucket compared to the results which it has achieved.

Patent Office Examiners.—The Civil Service Commissioners announce that an examination for the purpose of filling 10 vacancies for Assistant Examiners in the Patent Office will commence on May 4. The examination will be confined in the main to candidates who have served in His Majesty's Forces and will consist of a qualifying examination, followed by interview by a Selection Board. The subjects of the qualifying examination are English composition, *précis* writing, general knowledge, and one of the following: General chemistry, electricity and magnetism, mechanics and mechanism. The limits of age are 20 to 30. The initial salary is 150*l.* per year, together with a war bonus. Copies of the regulations and forms of application may be obtained on application to the Secretary, Civil Service Commission, Burlington Gardens, London, W. 1. March 4 is the last day for making application.

Personal.—Dr. Edward Ardern, F.I.C., formerly chief chemist, has been appointed consulting chemist to the Rivers Committee of the Manchester Corporation, and has joined Mr. S. E. Melling, F.I.C., consulting chemist to the Salford Corporation, public analyst for the County of Chester, &c., in practice as analytical and consulting chemists, at The Cliff, Higher Broughton, Manchester.—We are informed that the British Electrical Federation, and most of its member companies, have returned from the Manchester Hotel, Aldersgate-street, to Electrical Federation Offices, 88, Kingsway, over the Holborn Station of the Piccadilly Tube Railway. As the Government has retained part of the building, the Engineering and Stores Departments of the federation are for the present located in adjacent premises, at 11 to 13, Southampton-row, while the Electrical and Industrial Investment Company and other finance companies are at 4, Broad Street-place, E.C.

THE PHYSICAL AND OPTICAL SOCIETIES' EXHIBITION.

The tenth annual exhibition of electrical, optical and other physical apparatus of the Physical Society was opened in the Imperial College of Science, South Kensington, on Wednesday last, and was kept open from 3 p.m. to 10 p.m. on that and the following day. These scientific exhibitions which Mr. W. R. Cooper, the senior secretary of the Physical Society, first arranged years ago and which had become one of the scientific events of the winter session, had to be suspended during the war. That they have now been resumed is mainly owing to Mr. F. E. Smith, F.R.S., who has meanwhile succeeded Mr. Cooper in the position of senior secretary. Originally the exhibition was planned for December, but it had to be postponed to a somewhat uncertain date. The Optical Society has joined the Physical Society in this year's exhibition. As the world in general, so the exhibition has progressed as to time and space. Formerly the exhibits were somewhat crowded on one floor and had to be examined on one day. This time two floors and two days were at disposal. The change as to time was made after consulting the exhibitors, we understand, and the arrangement certainly meets the convenience of visitors as well.

Broadly we may distinguish optical exhibits, mostly on the ground floor, and electrical exhibits on the first floor of the building, and we will observe that distinction in our notice. A sharp demarcation is, of course, out of the question, especially as we have to defer certain notices. A good many of the exhibits have already been described in connection with the several exhibitions of the war years; but the addition of a novel device to known apparatus may be as noteworthy as the apparatus itself. Two discourses were delivered on each of the two days, one by Professor A. O. Rankine on "The Use of Light in the Transmission and Reproduction of Speech"; the other by Professor F. J. Cheshire on "Some Polarisation Experiments."

The most interesting apparatus of Messrs. Adam Hilger were the interferometer, which is largely used now for prism correction and for glass testing generally, and has been mentioned by us; the quartz spectrograph, which we hope to describe on an early date; and the vacuum spectrograph, with the aid of which the Schumann region of the spectrum (ultraviolet) is now being investigated in the College. The instrument consists of a horizontal copper tube, tinned inside and outside, 10 in. diameter, about 3½ ft. long, which is kept evacuated by a Gaede pump. At the one end is mounted a Rowland grating; the other end is closed by a headpiece in which the photographic plate is mounted above two slots, through either of which the light of the arc studied, *e.g.*, aluminium, enters the tube. The Schumann plate has the shape of a strip, about 1 cm. wide, so fixed in an aluminium frame that it faces the grating; the plates are exposed for about five minutes. With one setting the region from λ 500 to λ 2,000 can be examined.

Messrs. Chance Brothers and Co. exemplified the utility of their various screen glasses by simple experiments. The light of a metal arc (iron) falls on a piece of uranium glass or on a plate of barium-platinocyanide. When one of the firm's ultraviolet glass screens is interposed (to cut out the visible rays) the fluorescence of the uranium or of the cyanide remains visible, though the general illumination is stopped. On the other hand X-ray glass, a flint of density 1·9, cuts off the ultraviolet. Such devices were used during the war to produce signals by ultraviolet rays invisible to all but those provided with suitable cyanide screens. The light barium flint of the firm is colourless, but is characterised by a bluish fluorescence; the fluorescence is merely a surface effect, since the active rays only penetrate to a very small depth with this glass. The specimen of this glass, which was used for the demonstration, had a sad history, as it was almost spoiled by a globular spot of devitrified glass looking like a snow-white lens in a colourless glass; powerful strain effect can be shown to exist with glass near the globe by polarised light.

For his demonstration of the Sheringham artificial daylight, which we noticed some weeks ago,* Mr. L. C.

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* See Engineering of November 28, page 725.

Martin had this time fitted up three small rooms or recesses, each lighted by one powerful lamp. In the first the light of the lamp was reflected from a large curved white screen above the lamp; in the second the reflecting screen was dotted all over with squares of blue, violet and green to produce artificial daylight; in the third some bright red squares were added to the others so as to produce a less bright north-sky illumination. The dark squares, of course, absorb a good deal of light, so that a powerful light source is needed.

Several of the microscopes of Messrs. Charles Baker, of 244, High Holborn, were fitted with their ultra-condenser intended for use in metallurgical photo-micrographic work. This, in one form, consists of two cup-shaped glasses mounted on the top of one another in such a fashion as to secure total reflection and focal condensation of all the light received from above or from below. Another arrangement of this ultra-condenser was shown applied to the examination of a liquid or gas to be examined in a cylindrical vessel standing on the slide.

The Tallents spectroscopic camera of Messrs. A. W. Penrose and Co., of 109, Farringdon-road, E.C., is fitted with a replica diffraction grating which is mounted on the hypotenuse of a prism. The replica is made by the application of a cellulose preparation to a Rowland grating of 14,438 lines to the inch, curved to a 6-ft. radius; the replica is floated off and deposited on a plane glass surface which is coated with gelatine and by the application finally protected by a cover glass. The camera serves for the examination of colour filters, dyes, &c.

The principles of the Bawtree colorimeter of the firm were recently explained by Mr. Bawtree before the Physical Society. The instrument serves for matching colour shades with the aid of colour filters (coloured glasses) for future reproduction; the pattern is mounted at the one end of the long square box, a lamp at the other; the middle is taken up by a screen, half of plane glass, half of colour filters, and the proportion of the colour filters is varied until the tints of the beams passing through the filters and through the glass are matched. The Penrose double-platinised reversing mirrors are optical glass mirrors covered (by the Rheinberg process) with two coatings of platinum; the surfaces are said to be untarnishable and not to be scratched by a penknife; reversible mirrors replace the more expensive prisms in various optical instruments. The Penrose photogravure copy screens can be varied in the ruling ratio; the master ruling is, *e.g.*, 1 : 4 (*i.e.*, the width of the dark lines or squares and of the blank spaces are as 1 : 4), and in the copies the ratios are 1 : 2¼, 1 : 2, 1 : 1¾; the rulings are in platinum, and absolutely opaque.

Messrs. J. H. Dallmeyer exhibited as a novelty the Dallon fixed-focus telephoto-lens in a large and a small specimen, both of 12-in. focal length and 6-in. extension. The lens is composed of only two pairs (this is the novelty) of cemented glasses, made especially by Messrs. Chance; the lenses are said to be equal to the best anastigmat. In the series V, Dallmeyer "perfac" anastigmat lens four glasses are used, two in front of the diaphragm and two behind, the latter being cemented.

Messrs. Bellingham and Stanley, of 71, Hornsey Rise, exhibited an immersion refractometer differing from the Jena type by having the prism sleeve easily exchangeable. In their polarimeter the observer does not face the divided circle; the divisions are at the back of a disc and are read with the aid of a small mirror; the observer's breath does not condense on the divisions and the illumination is facilitated. The improved Abbe refractometer of the firm has been mentioned by us.

Messrs. Newton and Co., 72, Wigmore-street, W. 1, exhibit various examples of their long-range and other optical lanterns. The new cone filament shown for use in optical lanterns is a half-watt lamp, the tungsten wire of which, stretched between supports about 1·5 cm. apart, is coiled to a hollow cone to send out an intense light from the apex; in small halls without electric mains the current is taken from accumulators. New amongst the exhibits, theodolites, &c., of Messrs. E. R. Watts and Son, Limited, are the Carl Zeiss pattern levels. The level case is open both above and below to obtain ample illumination of the bubble, and the eyepiece can be fixed with its cap on either end of the telescope for collimating the instrument; the level is adjusted by a slow-motion micrometer. In the dumpy level the main illumination is from underneath, and the reading is taken at the eyepiece end by means of a mirror.

Messrs. W. Watson and Sons, of 313, High Holborn, exhibited only microscopes. Their Van Heurck microscope may be said to represent the one extreme of high accuracy and elaborate construction, their new form "service" microscope the other limit of a good, inexpensive microscope for students' use. Condensers for vertical illumination from a source of light by the side of the microscope were also shown. The Watson-Denne microtome cuts ribbons, 1 microm in thickness, with a 35-mm. travel.

The chemical balances of Mr. L. Oertling, Limited, deserve notice for their high delicacy and accuracy. Triangular balance beams for loads of 200 grammes turn with 0·1 milligramm; the beams are made of aluminium alloy, the pointers of angle aluminium.

We shall deal next week with a number of the other optical exhibits, but in the meantime we must pass on to exhibits of an electrical character.

Messrs. Evershed and Vignoles exhibited an example of their Dionic water tester. This is an ingenious apparatus for indicating electrically the amount of inorganic impurity dissolved in water. It consists essentially of a vertical glass tube with arrangements for filling and emptying, and in which a sample of the water to be tested is placed. Two contacts are fixed, one at the bottom and the other some distance up in the tube. These make electrical connection between the water being tested and a Megger, the firm's well-known resistance-measuring instrument which consists of a moving-coil ohmmeter connected to a high-pressure hand-operated generator. By means of the Megger the insulation resistance of the column of water is measured. An ingenious arrangement fitted to the water tester compensates for differences in temperature of the water tested. This consists of a thermometer sliding inside the glass tube and carrying a pointer which moves over an outer scale. The temperature of the water to be tested is read on the thermometer, and the thermometer with its pointer is then moved, and the pointer is set to indicate on the outer scale, the temperature which has been noted. The moving of the thermometer displaces some of the water, and so modifies the cross-section of the column of water which is being tested that the temperature is compensated for. The instrument is intended for use in connection with water-softening plants, industrial processes, &c. The work of a salinometer can be carried out by means of it.

We shall refer later to the display of thermionic valves made by the Edison Swan Electric Company, Limited. The other principal display of this company was their Pointolite lamp. This is now made in sizes of 30 c.p., 100 c.p., 500 c.p. and 1,000 c.p., and in conjunction with special resistances for use on circuits up to 240 volts. The lamp is really an arc lamp, but in size and general appearance resembles an ordinary incandescent bulb lamp. The bulb is filled with nitrogen and other inert gas, and has a filament made up by a combination of tungsten with refractory oxides. Adjacent to this a small knob of tungsten is carried on a conducting arm. On first switching-on the lamp the filament forms the circuit and glows. This filament then acts as an ionising agent, and in a few seconds the air resistance between the filament and the tungsten knob is destroyed, and an arc passes, the knob being connected by its arm to one of the poles of the lamp circuit. This arm is formed to act as a thermostat, and when the arc is struck the arm moves and breaks the circuit through the filament, the arc, however, being maintained and acting as the source of light. The lamp has very considerable efficiency, but its main claim is that the source of light is a point and that consequently it is of value in connection with optical work requiring focusing. In earlier forms of the lamp the current shunting arrangements were external, but the whole of the mechanism is now constituted by the thermostat inside the bulb, and the lamp may be placed in an ordinary lamp holder on any circuit.

Electrical laboratory and switchboard instruments of various patterns were exhibited by the Weston Electrical Instrument Company, Limited, and Messrs. Elliott Brothers (London), Limited. The Weston Electrical Company in particular made a very good display in this way. Messrs. Elliott's exhibit was more miscellaneous and included a portable Wheatstone bridge, a main's testing set and a tubular magneto and revolution indicator. This latter piece of apparatus was for airship and aeroplane work, and consisted of a magneto arranged to operate one or more revolution indicators. A new dial type measuring instrument was shown by Marconi's Wireless Telegraph Company, Limited. Examples both of ammeters and voltmeters embodying the new movement were exhibited. The arrangement was a hot-wire one, and depended for its action on the thermal expansion of the wire, the extension of which operated a spring controlling the pointer. The wire was connected to the spring by a bi-filar suspension which, in conjunction with the spring, gave the necessary magnification of the expansion of the wire. A valuable feature of the instrument was that the hot wire and its supports, together with the spring and pointer movement, could be rotated together around a common axis. This rotation moved the pointer over the fixed scale and was used for adjustment of the zero. The effect was that such adjustment did not affect the calibration in any way.

The great advances made in wireless matters during the war, and particularly in connection with the evolution of the thermionic valve, were well represented in the exhibition. A thermionic valve oscillation for generating high-frequency alternating currents for A.C. bridge measurements was exhibited by Mr. H. W. Sullivan, as also a three-valve receiver. A series of separate valves of various classes was shown by the Edison Swan Electric Company, Limited. They comprised service valves for wireless reception and transmission, Marconi valves made by the exhibitors, rectifying valves and examples of the Scott Taggart - Ediswan continuous wave transmitting valves for use with alternating current without separate rectifiers. Wireless work was also represented by Marconi's Wireless Telegraph Company, Limited, which showed their direction finder gear. This has been described recently in our columns and need not be dealt with again here.

In some way the most interesting wireless exhibit was that of the Marconi-Osram Valve Company. They consisted of a large series of valves illustrating recent advances in design and manufacture. The thermionic valve has now pretty well reached the stage of a definite piece of electrical apparatus which can be designed for particular services and outputs, with a fair chance that performance will correspond with the designer's intention. It is curious that the possibilities of the thermionic valve which was introduced as a rectifier by Professor Fleming in 1904, and which was later modified, the fitting of the grid by de Forest, were not properly recognised until the outbreak of the war. Since that time its development has been remarkable, and it is used not only as a wireless detector but in connection with wireless direction finding and special wireless work on submarines. War demand required the manufacture of the valve in large quantities and the output from the Osram G.E.C. lamp works at Hammersmith reached towards the end of the war an output of 4,000 valves a week. It is in these works that the valves shown by the Marconi-Osram Valve Company were made. Other firms, of course, participated in this remarkable expansion of output, notably the Ediswan Company, to whose exhibit of valves we have already referred. The whole story of these valves form an interesting illustration of the possibility of the development of the manufacture of scientific apparatus in this country. An interesting account of the work done for the Navy in this connection will be found in Professor Fortescues' British Association paper which was printed in our issues of October 10 and October 17 last.

Naturally there was little at the exhibition which in an ordinary way would be classed as engineering material, but an interesting exhibit by Messrs. Evershed and Vignoles, Limited, approached

that classification since it took the form of a 5,000 volt direct-current motor generator set. However, as the output was only 15 milliamperes at 5,000 volts we are afraid the set must be classed as a piece of physical apparatus. This, however, need not detract from its interest. It consisted of three permanent magnet generators coupled in a line and driven by a 220-volt D.C. motor. The high-tension generators had series wound armatures and were themselves connected in series to give the 5,000 volts. Terminals were arranged, however, so that the voltage of one or two machines only could be utilised if desired. An overload circuit-breaker of novel type was placed in the high-tension circuit. It consisted of a permanent magnet which held up a soft iron armature when the circuit was closed. Coils surrounding the poles carried the high-tension current and the effect of overload was to overpower the permanent magnet so that the armature was released. The circuit was actually broken on a double-break arm-break switch. The machines were mounted on wooden pillars on a wooden base and were connected by flexible couplings incorporating an ebonite flange to give the necessary insulation. The set was, of course, intended for experimental work.

(To be continued.)

"NEW DEVELOPMENTS IN HIGH VACUUM APPARATUS."

To the Editor of Engineering.

SIR,—In your issue of the 2nd inst. you reproduce a most interesting paper by Mr. Kothny on "High Vacuum Steam Ejectors for Marine Work," but, as Mr. Kothny makes several suggestions which are not in accordance with standard British marine practice and which may cause misunderstanding, the writer ventures to point out the discrepancies.

In the first place Mr. Kothny states that the recognised limits for vacuum for well-designed marine turbine surface condensers are 1·5 in., 2 in., 2·4 in., 2·75 in. h.g., for temperatures of 60 deg., 70 deg., 80 deg., and 85 deg. F. respectively, whereas the standard vacuum used by at least one geared turbine manufacturing firm in this country, namely the Metropolitan Vickers Electrical Company, Limited, for the same conditions are as follows: 1·2 in., 1·6 in., 2·2 in. and 2·6 in. for normal rating and, under some conditions, they may be as high as 1·1 in., 1·5 in., 2 in. and 2·4 in. When it is realised that the difference between 1·1 in. and 1·5 in. h.g. absolute pressure means a further expansion of the steam of 35 per cent. of volume, it can be seen that Mr. Kothny's figures are misleading as, presumably, the rest of his remarks are based on his first assumption.

The second point I should like to call attention to is the extremely small allowance of air leakage allowed both for turbines and engines as shown in Fig. 1. Take the case of turbines, the formula in Fig. 1 appears to be about 7·5 lb. plus 2·5 lb. per 10,000, whereas our standard British practice is about 3 lb. plus 5 lb., which gives a very much higher result over a large proportion of the curve. The difference for engines is equally startling. It is, of course, understood that the allowance for weight of vapour carried over with the air, as given in Fig. 2, is also allowed by English manufacturers.

The significance of the above facts is realised when considering Mr. Kothny's statement that the steam consumption for a steam ejector plus a turbine-driven condensate pump is lower than that of the twin beam air pump, a most startling suggestion.

The writer has made many calculations comparing various types of air-extracting apparatus for marine work, and he can assure the reader that, on British standards of air leakage and vacua, the consumptions of the type of ejectors discussed in this paper are very far in excess of a reciprocating pump of, for example, the Weir Dual type. Of course, due allowance can be made for re-heating in the hotwell, but the advantages sometimes claimed for this system are often very much over-stated.

Referring to Fig. 14, it would appear that in an American installation very much greater headroom is allowed for the condensing plant than is customary in modern British marine installations; usually the condenser bottom, with turbine work, is situated not more than 2 ft. 6 in. above the tank top, whereas the illustration would indicate 4 ft. to 5 ft., judging from the scale of the rest of the plant.

Mr. Kothny appears to dismiss the Le Blanc air-ejector as though it were of no very great importance in the States, whereas the writer happens to know that *over a year ago* there were 312 ships already equipped or being equipped with this type of apparatus. The list is too long to give in this letter, but the writer encloses a printed list of these installations. During 1919, it is probable that the further installations ordered would bring the total very near the figure of 500 mentioned by Mr. Kothny.

Finally, the writer would like to say that, in his opinion, an ejector system may be sometimes advantageous, but that each particular case must be carefully investigated on its merits to determine the most suitable plant with a minimum overall steam consumption.

Trusting that you will be able to find space for this letter.

Yours faithfully,

January 3, 1920. A. E. LEIGH SCANES.

THE STRENGTH OF DOMES.

To the Editor of Engineering.

SIR,—Recently I had occasion to work out the stresses in a thin dome, and compared them when finished to a graphical solution given in a well-known text book. It is easily shown that a thin spherical shell can be kept in equilibrium by internal stresses acting everywhere tangential to its surface (i.e., simple tensions and compression) when under its own weight. The graphical solution referred to above contains the following remarkable statement:—

"... at the crown itself there is no stress. This is one of the material points of difference between the dome and the arch, which latter construction has always a thrust at the crown."

It is a matter of common knowledge that a fall in temperature, or shrinkage of material, causes a tensile stress throughout an arch, assuming the abutments do not yield. Cases can easily be imagined where this would neutralise the thrust due to the arch's own weight. As far as the spherical dome is concerned, neither the compression across a line of latitude (imagining the crown as a pole) nor the circumferential tension or compression across the meridians is zero at the crown. This is easily demonstrated as follows:—

Let A B C D be a thin spherical shell resting on a smooth plane at D. B is the crown.

w = its weight per unit area of surface.
r = its radius.
t = its thickness.

Suppose the sphere cut by a cone of half-angle θ in the line of latitude A C.

Let p be the intensity of stress across this line of latitude (the directions of all the stresses are easily seen from the symmetry of the problem).

Weight of dome above A C

$$= w \times 2\pi r \times r(1 - \cos\theta).$$

Area over which stress p acts $= 2\pi r \sin\theta \,.\, t$.

Total vertical reaction

$$= 2\pi r \sin\theta \,.\, t \times p \sin\theta.$$
$$= \text{weight}.$$
$$= w \times 2\pi r \times r(1 - \cos\theta).$$

hence

$$p = \frac{w r (1 - \cos\theta)}{\sin^2\theta \times t} = \frac{w r}{(t(1 + \cos\theta)}.$$

Compression across lines of latitude at crown is the limit when $\theta = 0$ of

$$\frac{w r}{(1 + \cos\theta)} \text{ i.e. } \frac{w r}{2t} \text{ (and } \textit{not} \text{ zero)}$$

at point D the compression is the limit when $\theta = \pi$ of

$$\frac{w r}{t(1 + \cos\theta)} \text{ i.e. } \infty.$$

By considering the equilibrium of a small ring between two coinciding cones whose half-angles are θ and $(\theta + \partial\theta)$ it follows that the radial tension across the meridians (in a ring bounded by two lines of latitude which closely approach) is given in intensity by:—

Radial tensile stress

$$= \frac{w r}{t}\left[\frac{1 - \cos\theta - \cos^2\theta}{1 + \cos\theta}\right]$$

$$\left(\text{this equals 0 when } \theta = \cos^{-1}\frac{\sqrt{5} - 1}{2}\right).$$

Radial tensile stress at crown is the limit when $\theta = 0$ of

$$\frac{w r}{t}\left[\frac{1 - \cos\theta - \cos^2\theta}{1 + \cos\theta}\right]$$

$$\text{i.e. } -\frac{w r}{2t} \text{ (and } \textit{not} \text{ zero)}.$$

[In the case of a conical shell this tension is given by:—

$$\text{stress} = -w l \frac{\tan\theta}{t}$$

where θ = half-angle
l = length from apex (on the slope).]

If we place a heavy ornament of weight W at the crown:—

Radial tensile stress

$$= \frac{w r}{t}\left[\frac{1 - \cos\theta - \cos^2\theta}{1 + \cos\theta}\right] + \frac{W}{2\pi r t(1 - \cos^2\theta}$$

if W is large enough there will be tension in every latitudinal ring.

Both the compression across the lines of latitude and the radial tension then become infinite at the crown. This case is of little practical value.

Yours faithfully

G. P. MANNING.

P.S.—The "text book" is Marsh's "Concise Treatise on Reinforced Concrete," and the graphical method is reproduced from "Reinforced Concrete," by Marsh and Dunn, being based on a paper given by Dunn in 1904. The quotation is from page 200. The last paragraph on page 203 is surely a misprint.

102, Fordhook-avenue, Ealing Common, London, W. 5,
December 31, 1919.

[Our correspondent's treatment of the problem he discusses is far from complete. Obviously such a dome as he considers is statically indeterminate, and equilibrium is thus possible, both with and without any stress at the apex. This is easily seen by considering the case in which a small hole is drilled through the apex. The stress across this hole is then necessarily zero. With masonry domes the method of construction is such that in general there will be no stress across the apex. With reinforced concrete such a stress may arise, but the effect of this will, on the whole, be such as to reduce the average stress on the material, and our materials of construction being such as they are any error made on the assumption that there is no stress at the apex will, on the whole, increase the factor of safety. Of course, in all strictness the bending stresses on the material should also be taken into account. The fact that, so long as the loading is symmetrical about the axis of the dome, the centre of one of the two principal radii of curvature at any point of the deformed surface will lie on the axis, makes it a relatively easy matter to frame the differential equation for the deflection when bending stresses are taken into account. This equation, however, will in most cases prove incapable of solution in general terms, although an arithmetical solution is always possible for any particular case.—ED. E.]

"FLAME VELOCITY IN INFLAMMABLE GASES."

To the Editor of Engineering.

SIR,—In the first paragraph of the letter contained in your issue of the 2nd inst. it appears that Mr. Mason has misunderstood a remark in my former letter. It was his limitation of my hypothesis to closed cylinders which I regarded as inaccurate—not the words he used in describing my hypothesis.

After the second paragraph, in which Mr. Mason comments on a certain remark in my previous letter, he proceeds to refer to the work of Mallard and Le Chatelier. In this reference he makes an omission which I think I should supply. He does not mention his own contributions to our present knowledge of explosion phenomena. By reason of his work on this subject Mr. Mason is well qualified to criticise the suggestions I have put forward in the article under discussion, and I sincerely hope he will put forward his evidence for his belief if he considers my hypothesis wrong.

In the paragraphs numbered 1 and 2, Mr. Mason defines the position quite accurately. I accept these statements unreservedly, and I thank him for putting them forward so clearly. But I wish he had given some indication of his object in writing those paragraphs. Does he intend by contrasting my hypothesis with what is generally accepted as true, to show that my hypothesis is wrong, or does he, on the supposition that my hypothesis is true, desire to show where the usual interpretations of certain explosion effects require modification to bring them into line?

Regarding the last paragraph in Mr. Mason's letter, I do suggest that, if he thinks any part of my article of sufficient importance to write about, he ought to supply some sort of reason for his opinion, when he finds it necessary to disagree with me. He states that he is unable to regard the similarity between certain curves which I show as proof of their identity. I have not suggested that they were identical. What I did was to test my hypothesis by deducing from it the effect of cooling on the so-called "uniform velocity." Expressed as a graph the result agrees very closely with the experimental results found previously by Mason and Wheeler. This agreement is important, and is not disposed of by Mr. Mason's negative assertion.

Yours faithfully,

J. D. MORGAN.

13, Temple-street, Birmingham,
January 5, 1920.

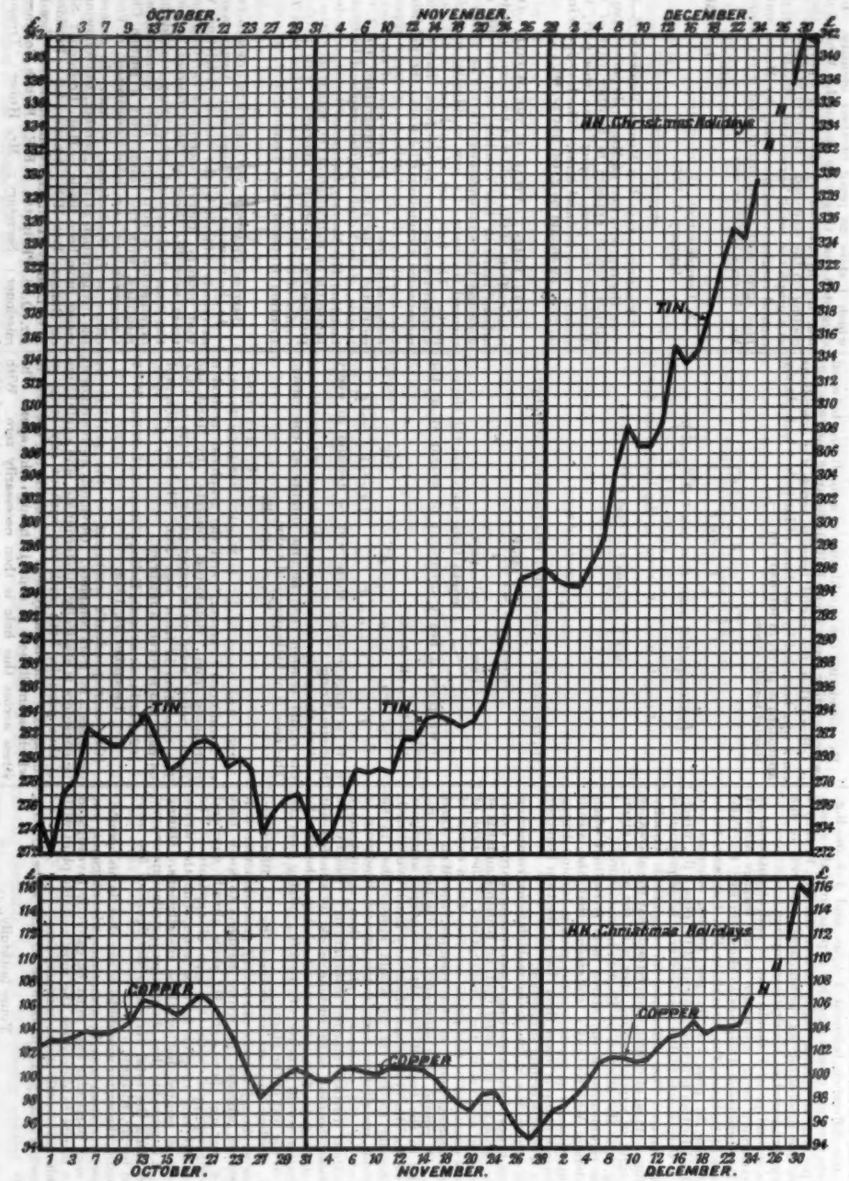
"PRODUCER GAS FOR MOTOR VEHICLES"—ERRATUM.—In the reproduction of Mr. D. J. Smith's paper on this subject, which appears in another part of this issue, dismissed for press earlier than this part, there is a serious typographical error. The last figure in the table on page 59 should be 2·6*d.* not 2*s.* 6*d.*

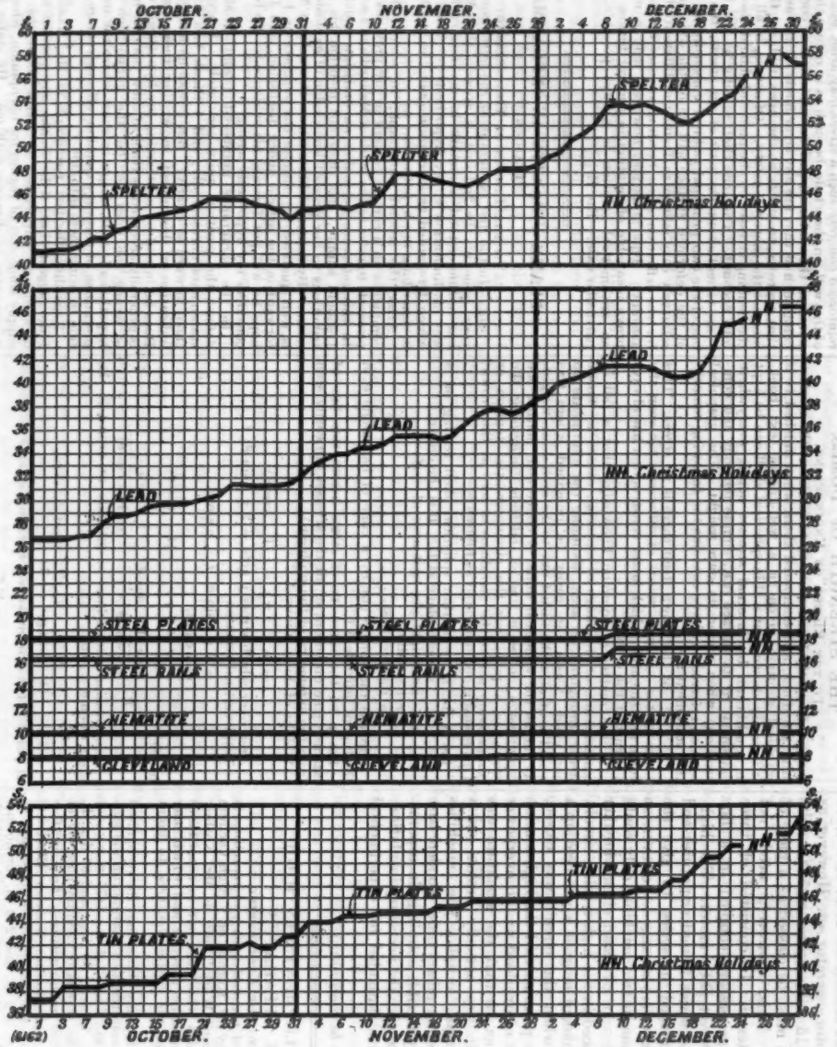
"THE TIMES" ATLAS OF THE WORLD.—One of the minor effects of the world war has been to render existing atlases more or less obsolete, and for this reason we welcome the announcement that *The Times* has commenced the issue of a new world atlas in 37 fortnightly parts. The first part is published to-day, and, if the standard reached in the specimen map we have seen is maintained throughout the work, the publishers' claim that it will be the best atlas in existence appears to be a reasonable one. The preparation of the work has been entrusted to the King's Cartographer, Dr. J. G. Bartholomew, of the Edinburgh Geographical Institute, and the fact that His Majesty has permitted it to be dedicated to himself is an indication of the importance attached to the publication in official quarters. Full particulars and copies of the first part can be obtained from *The Times*, Printing House-square, London, E.C. 4.

BRITISH CHAMBER OF COMMERCE FORMED IN VIENNA.—As the transaction of business in Austria was rendered extremely difficult by the various restrictions in force in that country, British merchants carrying on business there, says *The Board of Trade Journal*, considered that the time had arrived when they should have some organisation to help them. They, therefore, held several meetings, with the result that a British Chamber of Commerce has now been constituted in Vienna, with offices at 7, Giselastrasse, Vienna. In connection with the inauguration of the Chamber, the following appointments have been made:—Hon. President: Sir Maurice de Bunsen, late H.M. Ambassador; President: Hon. F. O. Lindley, H.M. High Commissioner; Vice-President: Mr. O. S. Phillpotts, O.B.E., British Commercial Commissioner; Secretary: Mr. Huber; Treasurer: Mr. Lowe.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal Markets.)





NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig iron. The prices given, in the case of steel plates, are for ship, bridge, and tank qualities, and those for steel rails are for heavy sections. The pig iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent £1. each, except in the case of the diagram relating to tin-plates, where they represent 1s. each.

PRODUCER GAS FOR MOTOR VEHICLES.*

[By D. J. SMITH, Member of Council.

FOR several years past, engineers have regarded with misgiving the steady advance in the price of liquid fuel, and the continuous inflation of oil share prices and the combination of great oil-trading organisations, give little hope of any reduction, even if the output is increased sufficiently to balance the demand. The author has read quite recently diametrically opposite statements as to the oil resources of the world and the possibility of maintaining a supply equal to all demands, and he is doubtless in the same position as many other engineers in that he does not know how near either statement is to the facts.

One thing, however, seems certain, and that is that at the present time the production of internal-combustion engines using liquid fuel is rapidly outpacing the supply of fuel necessary to run them. The output of motor vehicles in Great Britain is at present a somewhat nebulous quantity, but it promises to be great. The figures for the United States of America show that for the month of April, 1919, the output of 32 factories reached a total of 7,084 vehicles daily, which, allowing 300 working days, is equal to 2,125,000 vehicles per year. When manufacturers recover from the disorganisation caused by the war, this will probably be considerably increased. Disregarding the vehicles already running, and assuming a consumption of only 200 gallons of petrol per vehicle per annum, this new output alone will require over 400,000,000 gallons increase in the fuel supply to keep it running. At the present time, over two-thirds of the world's total output of petroleum comes from the United States, and, bearing this in mind, the author was much interested in an official report issued by the United States Government Printing Office in 1918, termed "Mineral Industries of the United States, Petroleum, a Resource Interpretation," and he gives the following quotation :—

"The output of 1917 cannot be maintained throughout 1918 without the arrival of critical conditions, and a continuation through 1919 is impossible. While the total demands for petroleum are increasing at a growing rate, the rate of production is slowing, and there is scant hope of increasing supplies from Mexico."

This certainly does not point to lower prices, but it may imply the early cessation of the export of petroleum by the United States. Other sources of supply will be available, but these are hardly likely to affect prices as they will probably come under the control of the existing oil-marketing organisations, which have so far held the motor industry as in a vice. Even benzol, from which so much was expected, is now being exploited, and a letter of protest from the secretary of the Automobile Association and Motor Union appeared in the *Motor Trader* of July 30, 1919, stating that the petrol companies were distributing a product called benzol at a price which did not allow it to be retailed at less than 3*s.* per gallon.

If the motor vehicle industry is to develop as it should do, cheaper fuel is essential. Quite apart from the question of cost, however, it is very inadvisable that such a vast industry should depend on what is practically a single source for its fuel supply, and on a fuel which has to be largely imported from countries which take little from Great Britain in return, and which also has to suffer from so much juggling in handling, as witness the great difference between the present prices in America and here.

With vehicles using petrol, the fuel costs can, apart from a lower price, only be reduced by a greater economy in its use. This does not appear very probable, as the internal-combustion engine seems to have reached the limit of its economy for commercial work and further savings can only be looked for in the direction of reducing the vehicle weight in proportion to the load carried.

A widening of the field of suitable fuels must be all to the good of both the vehicle user and the manufacturer, and must have a steadying effect on prices and largely increase the use of mechanically-propelled vehicles in places where liquid fuels are not readily available. A greater part, if not all, of the vast sums now being spent abroad for petrol could be saved to this country if solid fuels were used on all heavy vehicles, as the home production of liquid fuel might then be sufficient to supply the lighter vehicles. In any case, the author does not consider that the automobile industry of this country will rest on a sound basis until it can rely entirely on home-produced fuels. Practically, it does not cost the United States anything at all for fuel to run all vehicles in the country. Even the comparatively small labour cost of refining and handling the oil over there must be more than covered by the increased prices (excluding freight) at which the fuel is sold here, and Great Britain is, therefore, handicapped by having to pay the fuel bill of the United States as well as its own. The motor vehicle saved the situation in the recent railway strike, but it did so on imported fuel. A serious and extended labour dispute in the States might gravely affect the liquid fuel supply here. Motor transport will very shortly be a greater asset to this country than its railways, and all possible steps should be taken to secure a safe fuel supply for it.

Solid fuels present the only method whereby the high cost of liquid fuels can be countered and the general position made less unsatisfactory, and these can be used without destroying any material from which liquid fuels might be extracted. For instance, coke, charcoal and dried peat represent the residue left after the liquid fuels have been extracted, so the utmost value is got out of the material used in providing fuel for both light and heavy motor vehicles. In the case of anthracite, there are practically no volatile constituents, so this fuel, if used directly, entails no loss to the liquid fuel supply. It has long been the author's firm opinion that every material from which any form of liquid fuel is obtainable should, before being used, be subjected, as far as it is possible to the process necessary to extract such fuel. The residue is frequently as valuable, when properly treated, as the complete fuel was in the original state, weight for weight, and the volatile constituents which are recovered are often alone more valuable than the fuel from which they were obtained. The best known example is the distillation of coal in the process of making coal-gas. One ton of coal would propel a 5-ton steam wagon about 160 miles, the fuel then being completely destroyed. If subjected to distillation, the 1 ton of coal would give 13,000 cub. ft. of coal gas, and taking 250 cub. ft. of this gas as equal to 1 gallon of petrol, this would propel a 5-ton internal-combustion-engined vehicle 312 miles. But after allowing for the fuel used for the retort, about 10 cwt. of coke would still remain, and at 3 lb. of coke per mile, a 5-ton producer gas vehicle would run a further 373 miles on this, or a total of 685 road-miles, as against 160 miles on 1 ton of coal burned directly. In addition to this, a large quantity of very valuable by-products would remain. The author has taken no account of benzol, as he has calculated the gas at its full calorific value, but by extracting the benzol even better results would be given from an economic point of view. The utilisation of 10 cwt. of coke used in a vehicle fitted with a portable producer-gas plant would, therefore, give over double the mileage obtained from the direct combustion of 1 ton of coal, which in addition causes the loss of all its valuable volatile constituents.

The author does not propose to go into the question of producer efficiency, composition of gases, &c., as these are quite apart from the object of this paper, and are fully dealt with in all the standard works on gas engines and producers. That there is no doubt about engines being able to run satisfactorily on producer gas, the millions of horse-power already in use amply prove, and few engineers would argue that there would be any experiment in manufacturing a motor vehicle engine to use this fuel.

The stumbling block up to the present has been the producer, and it is to the method in which the producer has been modified for use on motor vehicles that the author proposes to devote himself in this paper. Whether the efficiency of a producer is 95 per cent. or 75 per cent. is not of vital importance when there is such a wide difference in price between petrol or paraffin and the fuels used in the producer. The author has, however, kept efficiency as the chief consideration in the design of his producer, and he can state definitely that this is very high, as would be anticipated by consideration of the method of working.

Before proceeding further, the main advantages and disadvantages of the use of producer gas as a fuel for vehicle propulsion may be stated :—

Advantages.—(1) It allows the use of home-produced fuels, fuels, moreover, of which some are regarded at present largely as waste products, such as anthracite duff. Non-caking bituminous coal or coke can be used, but as there are many uses for them, while there are few for the duff, there is no reason to use any other, so long as it is available at low prices.

(2) It is safe, and eliminates all chances of fire, and would greatly reduce the insurance premiums on vehicles and the premises in which they are stored.

(3) Compared with coal gas, it does not call for labour in its preparation, or the consumption of fuel of commercial value in its production.

(4) It eliminates the perishable gas bag, which generally renders it impossible for a vehicle to get under a crane for loading or unloading goods.

(5) It allows a vehicle to travel the same distance as on petrol without taking in fresh fuel.

(6) It is a fuel of almost unvarying quality and eliminates mixture troubles and the need for more or less troublesome mixing valves.

(7) It is the cheapest source of power which can be adapted to motor vehicles known at present, and with coal at 40*s.* per ton is equal to petrol at 2¼*d.* per gallon when used in the same engine.

(8) It is lighter than a compressed gas installation and occupies less room, and eliminates expensive compressing costs.

(9) It requires no pressure, and there is therefore no danger. The pressure in the plant is always less than atmospheric, so if there is any leakage, it is of air inwards.

Disadvantages.—(1) The time taken to start from cold ; this averages from 15 minutes to 20 minutes, but the fire will keep alight all night if desired and can be ready for a start in about 4 minutes or 5 minutes the next morning.

(2) The weight of the plant over and above that of the fuel, which for a 50 h.p. engine is about 2 cwt. The tare of the average 3-ton lorry is about 3 tons 15 cwt., so this is not a high proportion.

(3) The necessity for an occasional cleaning of the plant. This involves a wash out of the scrubber every morning, which takes about 5 minutes and can be done while the fire is being lighted, so means no loss of time. The plant should be started up in a well-ventilated space, as the gas is harmful if inhaled in quantities for any length of time. Once the plant is going, there is no escape of gas.

(4) The time, 3 minutes or 4 minutes, taken to start after any lengthy stoppage.

(5) An increase of 75 per cent. in weight of fuel (including water) to cover any given distance, as compared with petrol, unless the engine is adapted to give higher initial compression, in which case the disparity in weight is considerably reduced.

At the present time only two types of vehicles use solid fuel, the steam vehicle directly and the electric vehicle indirectly. Both these are noted for their low fuel cost, and this has much to do with the growing popularity of these types. In the case of the steam vehicle, a low upkeep cost, due to the vehicle being designed for its work with no attempt to incorporate the latest pleasure car practice (probably quite unsuited for heavy vehicle work) is also a powerful factor, but the cheapness of fuel is a great consideration.

The user generally only regards the value, not the weight, of the fuel used, and it would be a very great drawback to the internal combustion vehicle if, in order to get equally cheap running, it had to consume the same weight of fuel as the steam vehicle. A 5-ton steam lorry running on rubber tyres and weighing, with its load, 12 tons, should not consume more than 1 cwt. per 8 miles. With coal at 50*s.* per ton, this is equal to 0·31*d.* per gross ton-mile. A 5-ton petrol lorry, weighing, with its load 9 tons, would consume 1 gallon per 6 miles, and this with petrol at 3*s.* per gallon is equal to 0·66*d.* per ton-mile, or more than twice the cost of the steam vehicle. Owing to the great difference in the weights of the vehicles, it is necessary to take gross weight for comparison, but taking the net load of the two vehicles, the cost works out at 0·75*d.* per ton-mile for the steam vehicle and 1·2*d.* for the petrol vehicle. The steam vehicle is, however, using 14 lb. of fuel per mile as against 1·3 lb. for the petrol vehicle, but as the cost of a ton of coal is little more than that of 1 cwt. of petrol, that is, 50*s.* to 42*s.*, this is not considered.

With such a great disparity in the prices of the fuels, it is quite obvious that the petrol vehicle, even with its much more economical prime mover, cannot compete with the steam vehicle in cost of fuel. By the use of producer gas, the internal-combustion vehicle is able to use the same fuels as the steam vehicle, and, owing to its higher efficiency, to consume far less in proportion to any given work.

Unfortunately, the chief data relating to producer gas deal with the weight of fuel per brake horse-power, and it is somewhat difficult to transform this into ton-miles in comparison with a steam vehicle. It is, however, well known that small steam motors are comparatively extravagant in fuel, and it is doubtful if the consumption is less than 3 lb. per horse-power per hour. A petrol engine, taken in its "commercial state" as usually found in motor vehicles, would consume 1 lb. of petrol per horse-power per hour. An engine designed for producer gas would probably not use more than 1·2 lb. per horse-power hour, taking good anthracite as a basis so it can be seen that producer gas provides a fuel as low in price as that used by steam vehicles and nearly as low, measured in quantity for any given work, as that used by petrol vehicles.

The comparative costs are given in Table I :—

TABLE I.

—	5-Ton Steam.	5-Ton Petrol.	5-Ton Producer Gas.
Price of fuel	50*s.* per ton	3*s.* per gall.	55*s.* per ton
Gross load	12 tons	9 tons	9·5 tons
Pounds of fuel per mile ..	14	1·33	1·56
Pounds per net ton-mile ..	2·8	0·26	0·312
Cost per pound, pence ..	0·268	4·5	0·294
Cost per gross ton-mile ..	0·31	0·66	0·048
Cost per net ton-mile ..	0·75	1·2	0·091
Equivalent cost of petrol per gallon	1*s.* 6*d.*	3*s.*	2*s.* 6*d.*

This indicates that by using producer gas in an internal-combustion engined vehicle, the steam vehicle is no longer the cheapest in fuel cost, although the fuel for the producer gas vehicle is taken at a higher figure, the current market figure at this time. It is in the weight of fuel, however, that the greatest saving is accomplished ; the steam vehicle uses about nine times greater weight of fuel per mile than the producer-gas vehicle. Assuming a journey of 100 miles, the steam vehicle would therefore have to carry over half a ton more fuel than the producer-gas vehicle in order to accomplish the full distance. If other things were equal, this would seem to point to the extinction of the heavy steam vehicle, but this is not likely to happen until the makers of internal-combustion vehicles build a vehicle which can take the place of the steamer with its extremely low upkeep and repair cost and great reliability. This is the type of vehicle which the author hopes to see adopted for the use of producer gas, and which is dealt with later in the paper.

In view of the fact that the railways of the country have practically broken down, there must be an enormous extension in the use of heavy road transport if industry is to carry on, and it is essential that this transport should be run as economically as possible and also in such a way as not still further to encroach on the fuel supply of those vehicles for which liquid fuel is essential. The author, therefore, considers the application of producer gas to vehicle propulsion as a matter of first importance, especially in view of the fact that this method of propulsion is accompanied by the following advantages in the wording of the Inter-Departmental Committee on Gas Traction (1919).

1. Lowest known fuel cost.
2. Large radius of action without recourse to compression or the use of containers as with coal gas.
3. Use of home-produced solid fuels.
4. Low cost of upkeep.

The method in which it may successfully be applied can now be dealt with.

Produces Gas for Motor Vehicles.—The application of producer gas to motor-vehicle propulsion has already attracted much attention. It is very difficult to state definitely at this time who originated the idea, but it

* Paper read before the Institution of Automobile Engineers, January 8, 1920.

seems very probable that the first internal-combustion engined vehicle that ever ran on common roads was driven by producer gas. In 1819 David Gordon, who was the patentee of a portable gas-producing apparatus, endeavoured to form a company to build mail coaches and other carriages on his system, using a gas vacuum engine. Details of Gordon's apparatus are meagre, but it is described as comprising a "carbonic oxide" furnace. Coal gas had just come into use at that period, and as Gordon was in collaboration with Murdoch at Soho, his gas producer might have been a carbonising apparatus as used for the production of coal gas. There is no record that Gordon ever propelled a vehicle on his system.

In 1823, Samuel Brown patented a vehicle propelled by gas, and a vehicle constructed on his patents is said to have ascended Shooter's Hill at high speed. Brown's engine we are conversant with, but what type of gas producer he used is not known to the author. This, however, would appear to be the first internal-combustion vehicle which ever ran. The high consumption of Brown's engine would put gas bags or cylinders of compressed gas out of the question, even if such articles were available at that date. Brown was fully alive to the possibility of gas propulsion of boats, and ran a boat on the Thames using his apparatus, and formed a company called the Canal Gas Engine Company, but this soon went into liquidation. Brown was undoubtedly before his time and shared the fate of so many other inventors who lived before the world was in need of their work.

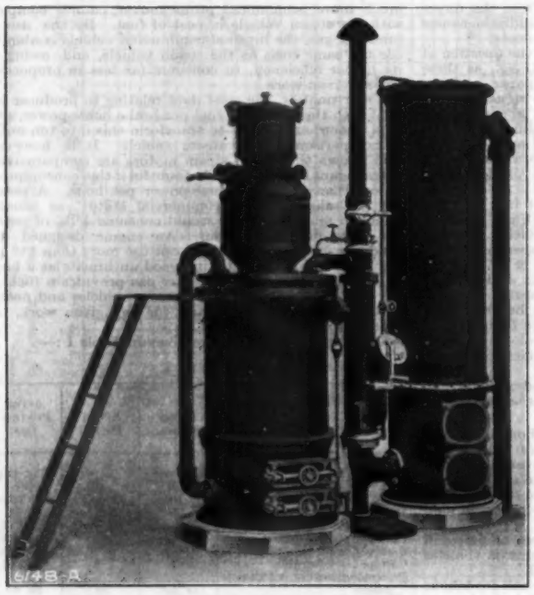


FIG. 1.

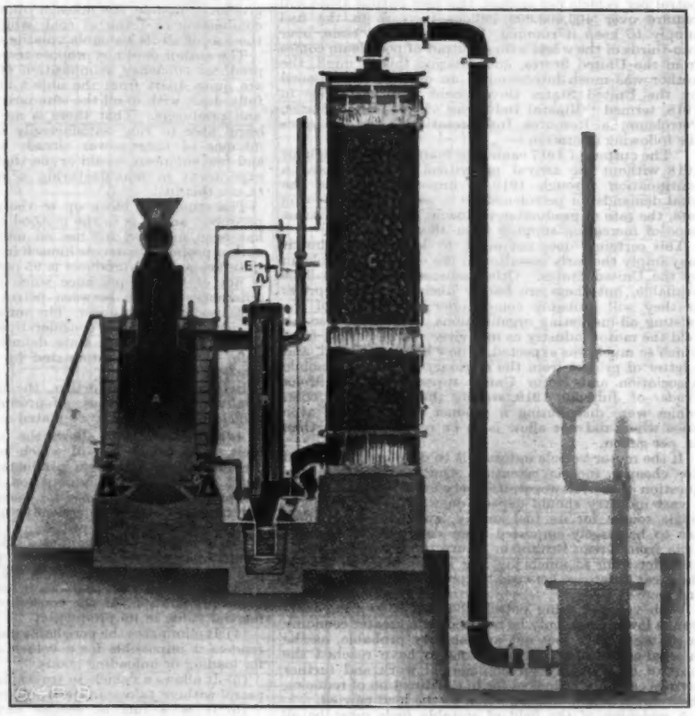


FIG. 2.

FIGS. 1 AND 2. 30-HORSE-POWER GAS PRODUCING PLANTS.

Producer gas, as applied to internal-combustion work, did not, however, receive much attention until stationary gas engines began to be built in large sizes, and were, therefore, costly to run on town gas, and could not moreover be used at all where public gas supply was not available. It is true that gas producers, or as they were termed, carbonic oxide furnaces, were used for heating purposes and many patents were taken out about 1860 for such furnaces, but this use is not within the scope of this paper. The success attending the use of stationary producer-gas engines and the very low cost of running them were the reasons which led many engineers, including the author, to see if this source of power could not be successfully adapted to motor-vehicle propulsion.

The problem of running the engine of a motor vehicle on producer gas is a very different one from that of running a stationary engine where weight and size of plant need hardly be considered and flexibility is not important. Provided that room could be found and the vehicle could carry the weight involved, it would be quite possible to use any form of stationary producer on a motor vehicle as far as furnishing the gas to the engine is concerned. A 40-h.p. to 50-h.p. stationary producer plant would weigh about 3 tons, and would fully occupy the loading space of the vehicle. It would also require about 1¼ gallons of water per horse-power or, say, 680 lb. per hour for its operation. Even if by the use of pressed steel the weight of the producer plant was reduced as far as possible, the size and high consumption of water would still remain and would render its use impracticable.

Failure to adapt gas producers to motor vehicle work has chiefly been due to the fact that the stationary plant has been taken as a basis, and every effort has been concentrated on reducing it in size and weight, while the features which render the ordinary producer impossible for motor-vehicle work still remained. As this paper deals with the adaptation of apparatus to use this form of fuel, it will be necessary to point out these features and to indicate why they must be eliminated before it can be successfully applied to vehicle work. Fig. 1, below, shows a stationary gas producer of good design of about 30 h.p. The size is indicated by the ladder on the side of the producer, and the proportion of the scrubber in relation to the producer should be noticed. A producer of this type depends entirely for its satisfactory working on the care and attention given by the man in charge. It has no moving or mechanically-operated parts. The fire having been lighted, fuel is fed into the producer by the attendant until the hopper is full. Only a thin layer of the fuel is burning at the bottom, the remainder of the fuel above this being exposed to the full heat of the fire, and all the hot gases are drawn up through it. If there are any volatile constituents in the fuel, and even in good anthracite there is a certain proportion, this is the best possible method of distilling them off, but the worst possible method for direct use, as any portion of these volatile constituents would gum up the engine; a very large scrubber has therefore to be fitted, in order to eliminate them, and this requires a large quantity of water, usually about 1½ gallons per brake horse-power hour. It will thus be clear that if a producer which is liable to give off tar or volatile matter is used on a motor vehicle, it would not be practicable to fit a scrubber large enough to deal with the gas efficiently, nor would it be possible to carry the quantity of water required for anything but a very short run.

As the fuel is consumed, a layer of ashes is deposited on the bars, which unless periodically removed, deadens the fire and the production of gas falls off. To remove these ashes, a fire door has to be opened so that they may be raked out by the attendant, and this has to be carried out quickly, or air will enter which may stop gas production or cause an explosion in the producer.

The deep bed of fuel also burns hollow, which tends to stop the full gas production. If this is knocked in by the attendant, the resulting disturbance generally destroy the production of gas so that the engine stops, and the producer has to be fanned up to get it to work again. The poking of the fire, to destroy or prevent these hollows, has to be carried out by the attendant through small holes normally closed by plugs, and as it is impossible to see what is happening it is not a very efficient operation.

The feeding of the fuel is performed by hand, and the fuel passes through an air lock, as it is essential that no air be allowed to leak into the generator during the operation. If, as occasionally happens, the attendant leaves both doors of the air lock open, either the engine stops or an explosion occurs. With fuel fed in this manner, it is quite obvious that there is at one time too much fuel in the producer, and at another too little. In any case, there is no connection between the quantity of fuel fed and the work that is being done, and, therefore, the quality of the gas must be very variable.

The supply of water to the producer is a most important point in view of the part played by the water vapour in the composition of the gas. The control of this is generally left to the attendant, who regulates it without anything to guide him as to the quantity required, though in one or two cases the suction of the engine is made to control the feed of water, but even here there is no definite regulation.

The inflexibility of the ordinary producer is bound up with the lack of control of the water supply and the form of fire bed used. If it is assumed that a producer is working on a steady load, air is being drawn over the surface of the water in the vaporiser and takes up a certain quantity of steam. If the load is suddenly increased, more air would pass over the water, but no increase of steam would be available, in fact the tendency would be to cool the water down and decrease steam production. The gas would therefore be of lower quality, and the engine, instead of responding to the increased load, would stagger and possibly stop. Even if the steam were available, the fire, possibly with a layer of ashes between it and the bars and a bed of dead fuel above it, cannot respond rapidly, and would be cooled out by the sudden increase of steam drawn through it, and the quality and quantity of the gas would be still further reduced.

When, about ten years ago, the author first began to give this matter attention, engine flexibility was not considered of such importance on commercial vehicles, and it did not then appear that it would be a great drawback if a constant-speed engine had to be used with producer gas. The most serious trouble that had to be faced was the cleaning of the gas, and it did not appear possible in the restricted space available on a motor vehicle to fit a satisfactory scrubber that would deal with the gas given off, which contained certain volatile matter as well as dust, and, therefore, had to be washed or scrubbed before it could be used in the engine. The great size and weight of the producer, even when reduced as much as possible, also rendered the scheme impracticable, and the author determined to depart from standard practice and evolve a suitable producer for vehicle work. One reason for the great size of the normal design of producer is the fact that a very large quantity of fuel is carried on it at all times, see Fig. 2, above, and in this it resembles the old surface carburettor.

The need for this deep fuel bed, apart from the fact that it permitted of fewer openings of the doors for stoking, was not clear to the author, yet the standard authorities admitted no escape. Latta, for instance, states that the fuel bed of a producer using anthracite peas should be not less than 30 in. deep to give the best results, while with larger fuel and coke another 12 in. or so was necessary. This in itself made the producer very large, and also called for the presence of a hundred-weight or so of coal in the producer itself.

The fuel bed in an ordinary producer is divided into zones:—

1. The ash zone.
2. The combustion zone.
3. The decomposition zone.
4. The distillation zone.

The second zone is the one in which the actual work is

done, the rest give trouble, especially the first and fourth, the gradual deepening of the first deadening the fire and needing periodical clearing away, which could only be done with the engine stopped, and the fourth giving off the volatile constituents of fuel, which it was almost impossible to eliminate on a motor vehicle. The author, therefore built a producer in which only the combustion zone existed.

To keep this thin bed of fuel wholly as a combustion zone and to maintain its shallowness, two things were necessary: (1) A regular feed of fuel in small measured quantities. (2) Continuous agitation of the whole fuel bed, in order that no channels or holes in the fire might occur and that all ash might be constantly sifted out and the fuel bed kept light and porous to give easy passage to the air and water vapour through it. The depth of the furnace chamber in the producer was approximately 12 in., the depth of fire being only about 6 in., all of which, while working, was incandescent.

Since the fresh fuel was regularly fed, it was at once sifted into the incandescent mass of fuel and all volatile constituents were eliminated, the hot zone above the fire in the producer chamber dealing with those not broken up in the fire. This method of working quite eliminated the drawbacks due to the distillation of the fuel and the passing over of any volatile constituents which could give trouble in the engine, and not only could anthracite be used, but also other fuels containing a fairly high percentage of volatile constituents.

The author is fully aware that it is generally regarded as impossible to work a suction gas producer successfully with such a thin bed of fuel, but he can only state that it does work and works extremely well, and after severe tests has shown no drawbacks. Using anthracite, semi-anthracite and hard non-caking steam coal, only dust is found in the scrubber. A sample analysis gave:—

	Per Cent.
Carbon	90·06
Volatile matter	5·05

This was practically the analysis of the fuel which was used, and represented, in fact, merely the dust drawn off by the suction of the engine from the fuel as it fell into the producer and before it could reach the fuel bed.

This method of working also quite eliminated another serious trouble found with a deep fire bed, namely clinker. This, in ordinary producers, forms rapidly, and by closing up the grate apertures, reduces the yield and quality of the gas. The clinkers also form on the refractory lining of the producer and have to be barred off, a tedious operation and one which rapidly destroys the lining. Clinker is fused ash, and as no ash is allowed to form in the author's system, there is no clinker.

The feed and grate mechanism were driven by the engine of the vehicle, and a mechanical ash discharge was also added. This enabled the size of the producer to be still further reduced by doing away with the necessity of providing an ash pan large enough to contain the ash formed during some hours' running. The necessity for stopping the engine to clear out the ash was also eliminated.

Several important advantages resulted:—

1. A reduction in size and weight due to the small quantity of fuel carried in the producer.
2. The elimination of distillation of the fuel with all its troubles.
3. The prevention of clinker.
4. A self-acting fuel feed and ash discharge.

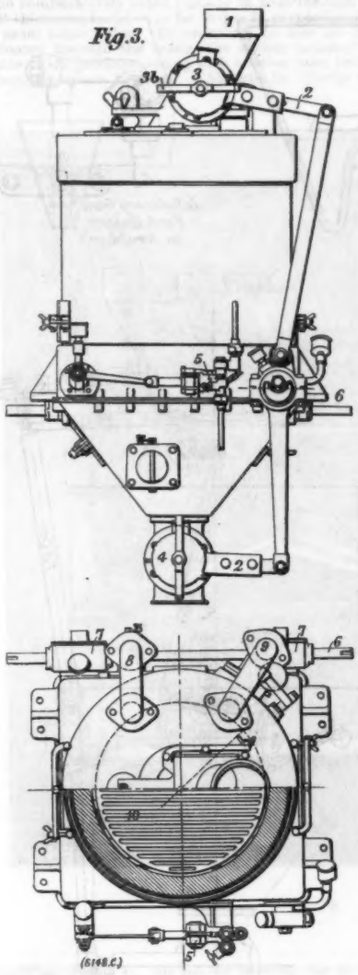
The results of the author's early experiments clearly showed that water could not be directly fed to the fire if the best results and extreme flexibility were required, so that it must be fed as steam, and that in order to keep the quality of the gas constant, the air passing to the producer must be used as the regulating medium for the steam supply. A small vaporiser or boiler was, therefore, fitted to the producer heated by radiation from the fire and the passage of gas through a channel formed in it (see Figs. 3 and 4). As the content of this vaporiser is small, the pump used in the early experiments was retained, and this fed the water to the vaporiser, but in order to economise heat, the water passed first through a water jacket surrounding the gas pipe from the producer (see Fig. 5). This feed heater on the gas exit pipe is a common feature in producer practice, but on vehicle work where no scrubbing or cooling water can be carried, it has an extra value in cooling down the gases as well as increasing efficiency.

The water in the vaporiser being at a temperature of approximately 180 deg.—200 deg. F. while the plant is running, the air drawn over the surface of the water picked up water vapour satisfactorily for steady loads, but any sudden increase in the quantity of air admitted did not meet with a corresponding increase in the steam supply, rather the reverse. The author, therefore, fitted a throttle to the air inlet to the vaporiser, through which all air admitted to the producer must pass. This throttle was coupled to the engine throttle, so that as the engine throttle was opened the throttle on the air inlet was partially closed. The result of this was to lower the boiling-point of the water in the vaporiser, which then gave off steam freely owing to the drop in atmospheric pressure or slight vacuum to which it was subjected.

This regulation of the steam and air supply in proportion to the gas required gave the necessary flexibility, and also, as steam was available and largely raised on heat which would normally be wasted, no detrimental effect was exercised on the fire, the proportion of air and steam always being maintained, the quantity only varying. The reserve of hot water in the vaporiser is a valuable asset for enabling sudden demands to be met; it really acts in the same manner as an air vessel in a pump, by absorbing the shock of delivery and maintaining a steady output.

The fitting of the vaporiser or boiler brought into prominence the effect of the varying level due to the rolling of the vehicle on uneven roads. This was overcome after many failures by the simple device shown in Fig. 6. The water from the pump enters the vaporiser by the pipe A so long as the level is below the desired point, which is regulated by the height of the pipe B. When this level is reached, no more water enters, and thus the water in the vaporisers is not cooled out by an excess of water. The surplus water passes into the cup C, and is led to a channel in the ash pan under the fire-bars. This channel is filled with asbestos cord and coaks up the surplus water which is vaporised by the heat of the fire-bars. The delivery pipe is taken into the centre of the vaporiser and acts also as an overflow pipe. When the vehicle rolls, this pipe, opening near the centre of the vaporiser, is scarcely affected by the variations in level, and little, if any, of the water already

Fig. 3.



GENERAL ARRANGEMENT OF THE D. J. SMITH PORTABLE GAS PRODUCER PLANT.

1. Fuel inlet pipe.

2. Adjustable fuel feed and ash-discharge gear.

3. Fuel feed valve.

3a. Friction drive for feed valve.

3b. Handle for independent hand operation of feed valve.

(Note that the position of the handle indicates the location of the feed aperture.)

4. Ash discharge valve.

4a. Friction drive for ash discharge valve.

4b. Handle for ash discharge valve. (Similar to that on fuel feed valve.)

5. Water pump.

6. Main operating gear shaft driven direct from engine.

7. Totally enclosed and continuously lubricated driving gear for the fire-bar camshafts: these also drive the water pump, fuel feed valve and ash discharge valve.

8. Pipe conveying steam and air to the underside of the fire.

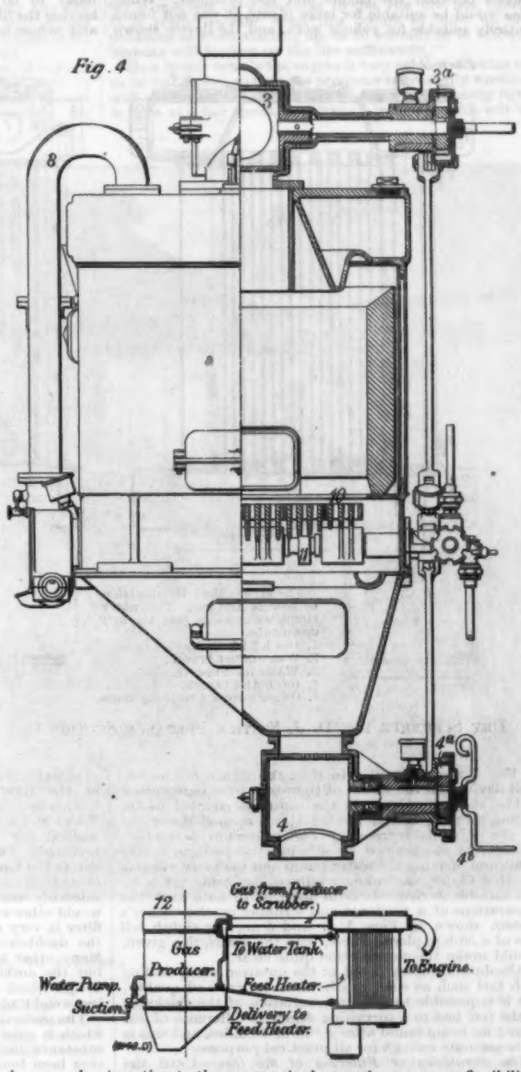
9. Air supply pipe from interior of jacket to vaporiser.

10. Fire bars, alternate sections pivoted at alternate ends, the free ends being vibrated section by section and successively by cams on revolving shafts.

11. One of the cams for vibrating the fire-bars.

12. Diagrammatic arrangement of producer and scrubber.

Fig. 4



in the vaporiser overflows. The stroke of the water pump is adjusted as far as possible to give the correct quantity of water, so that there should, in normal running on good roads, be little or no overflow from the vaporiser. Any water in excess of what can be absorbed by the asbestos-filled channel in the ash pan is discharged by the ash valve in the bottom of the ash pan.

The producer so far was only controlled by the speed of the engine, and, owing to the small quantity of fuel and water in the producer at any one time, it was necessary to control it by the speed or the load if conditions of working were to remain constant, as otherwise more fuel and water would be fed with the engine running fast with little or no load than would be fed with the engine running slowly at full load. Two devices were tried to overcome this. The first was a variable speed device between the engine and the producer. While this would be suitable for large plants, it was not found entirely suitable for vehicle work, and the device shown in Fig. 7 was adopted. In this, the stroke of the fuel feed device and the stroke of the water pump are varied.

The short free lever in the centre is coupled to the engine throttle, and as the throttle is opened the stroke of the lever is increased. The minimum permanent adjustment is obtained by altering the position of the crank-pin driving the water pump and the lever working the fuel feeder, the running adjustment being given by the variable device. It is of interest to note that the illustrations of a producer and scrubber on the author's system shown in Figs. 3, 4, and 5 are one-eighth full size of a 50-h.p. plant. These, with the description given, should make the construction quite clear.

Absolute accuracy is out of the question when dealing with fuel such as coal, which varies in size and quality, but it is possible to limit the variation of the thickness of the fuel bed to a surprising degree, a difference of less than 1 in. being found after a run of 50 miles, and this is quite accurate enough for all practical purposes.

The Scrubbing or Filtering of the Gas.—Until the invention of a producer which gives a gas free of all volatile constituents in the fuel, the scrubbing of the gas was the greatest difficulty in the way of adopting producer gas to motor vehicle work.

With a gas free from all tarry or condensible constituents, it is merely necessary to remove the dust held in suspension, and this is a very much easier task than scrubbing in a wet scrubber. The author tried many devices, notably coke-filled cylinders, trays of sawdust and pads of wood wool, asbestos wool, &c., but abandoned these in favour of the device shown in Fig. 6, which incorporates a feed heater and gas filter in one unit, thus economising room and weight. Coke and other materials form very efficient filters if the driver gives them regular attention and replaces them periodically with fresh material. To rely on the average driver doing this is, in many cases at least, to invite trouble with the plant, and the author thought it better not to rely upon any arrangement which called for renewal or cleaning at long intervals, but to insist on a daily clean out of the filter. It was essential that this should not demand any skill or require much time or trouble in opening up the scrubber and filter, and the arrangements shown in Fig. 6 fulfils these conditions. The device is in three sections:— 1. The feed heater. 2. The cooling tubes. 3. The filter tubes.

The gas from the producer enters the top header at the left hand end, and passes down the internal tube of the feed heater, which at the lower end is coned, and this tends to increase the velocity of the gas. The gas then expands into a settling chamber or pot, and in doing so drops a very large percentage of dust in suspension. It then leaves the settling chamber by an annular passage and passes up and down two or more banks of cooling tubes. In these tubes and the headers more dust is deposited. Finally, the gas passes up two or more large diameter tubes, which are fitted with fine gauze filters of conical shape, the filter fitting the bore of the tube at the lower end and terminating at a point at the upper end; to this a cross handle is attached, which allows the filter to be easily withdrawn through the door in the top header. An arrangement is also provided whereby any filter can be closed off and withdrawn for cleaning without stopping the action of the producer, but this is not likely to be required for vehicle work. The gas on leaving the filters is clean enough for all practical purposes and carries no more dust than is drawn into the air inlet of a carburettor when the roads are dusty. The cleaning of the filter is simple, and only takes 2 minutes or 3 minutes. The doors are opened, the gauze filters withdrawn and water is poured in at the top doors and all dust washed out; the gauze filters are then shaken and replaced. The water from the feed pump on the producer enters the feed heater at the bottom opening and leaves at the top to the vaporiser. This cools the gas considerably and also recovers much valuable heat which would otherwise be lost. The combined feed heater and filter is very small and can be easily accommodated on the dashboard on the side opposite to the producer. Many other forms of filters will, no doubt, be possible, but the author thinks it will be difficult to evolve a design which at once meets the requirements and is of less weight and size.

The material found in the filter is merely the fuel dust, which is quite dry and clean, and no trace of any tarry substance likely to cause trouble with the engine has ever been found.

For use with petrol engines having enclosed valves, some further filtering may be necessary owing to the very small clearance in the valve stems. (See notes on producer gas in petrol engines, to be given later.) For this purpose, the gas after leaving the scrubber can be taken through a small water seal, the gas pipe from the scrubber dipping about 1 in. or 1½ in. under the surface of the water, and the level of the water being maintained by a float chamber. The consumption of water would be very small, and, except for very long runs, no extra supply would be required and the float feed could be dispensed with.

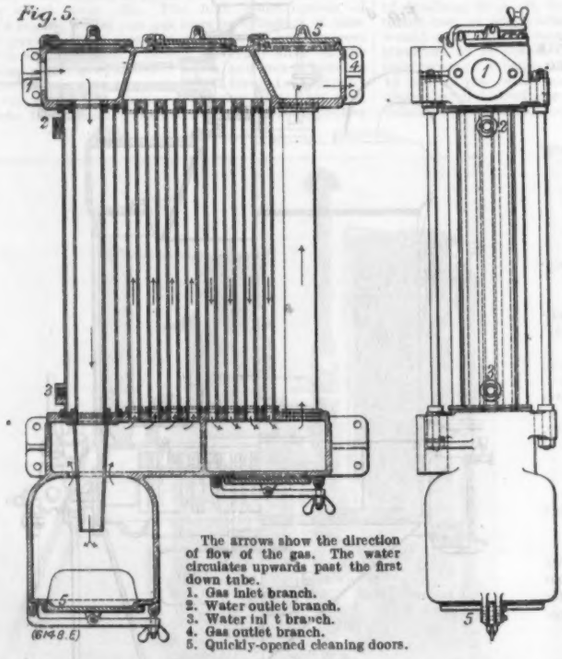
For use on agricultural machinery, tractors, &c., where the engine runs for long periods at high speed while the vehicle is either stationary or moving slowly, the scrubber should be so placed that it gets the benefit of the radiator fan blast, and a water filter, as fitted to the air inlet of some agricultural tractors, should be fitted on the induction pipe.

The water seal or filter chambers should be washed out at the end of each day's work.

Mixing Valves.—It was no easy matter to discover the best type of mixing valve or gas carburettor for producer gas used in an engine running at widely differing speeds and loads; on stationary work, the loads are in comparison rock steady, and the mixture, once set, needs no alteration in the case of engines governed on the throttle. In other types, the mixture is varied according to the load, the gas valve being given more or less lift and the air inlet remaining constant. Neither of these methods can be adopted on motor vehicles using the normal design of engine. The author tried many types of gas-mixing valves and gas carburettors with little success. Most of these were designed to work with gas delivered under a slight pressure, and were useless where the gas had to be drawn into the mixing chamber and where the amount of gas used in proportion to the air is large. Producer gas is also much richer at starting than when running, and needs a much larger air volume. The suction on the producer should also be maintained as steady as possible at all loads and speeds. The author finally adopted an arrangement in which no mixing valve as such was employed. The induction pipe or the gas pipe from the scrubber to the engine was enlarged in diameter for a short distance before reaching the inlet manifold. Close to the inlet manifold a throttle valve of the usual type, but rather more substantially built, was fitted. About 4 in. above the throttle valve, a number of slots were cut in the gas pipe, and over these a rotating sleeve also pierced with slots was fitted. By partially rotating the clip, the holes in the gas pipe could be varied in area to any extent. About 4 in. above these holes an ordinary automatically operated air valve having an area equal to half that of the gas pipe was fitted, the tension on the valve spring being adjustable. The air slots are opened wide for starting up and partially closed down as the engine gets away, when the chief part of the necessary air supply is then furnished by the automatic valve. When the throttle is nearly closed, sufficient air enters through the air slots. This device, while not perfect, answers remarkably well in practice, is extremely simple and cannot get out of order. The starting adjustment of the air sleeve is no more difficult than the same operation on a petrol vehicle, and there are no moving parts, apart from the throttle, in contact with the mixture. Variations in the fuel can be met by adjusting the tension of the spring on the automatic valve, an operation which takes a few seconds only. The design of producer gas mixing valves or carburettors will no doubt receive a considerable measure of attention, and the author would suggest this as an interesting field of research.

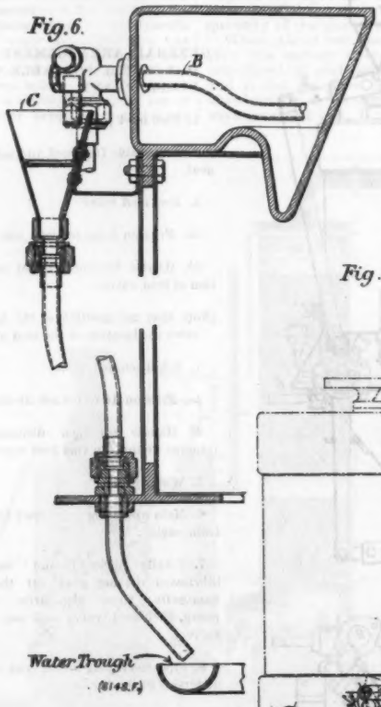
Refractory Lining of the Producer.—The refractory

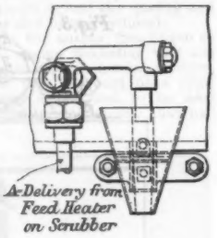
Fig. 5.



The arrows show the direction of flow of the gas. The water circulates upwards past the first down tube.
1. Gas inlet branch.
2. Water outlet branch.
3. Water inl t branch.
4. Gas outlet branch.
5. Quickly-opened cleaning doors.

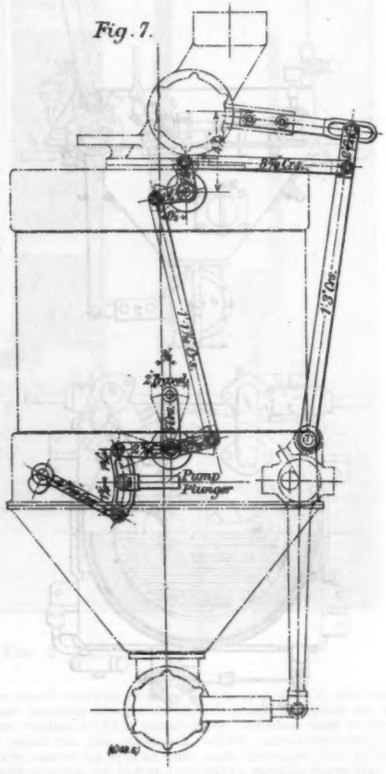
Fig. 6.





DRY SCRUBBER FOR D. J. SMITH'S PORTABLE SUCTION GAS PRODUCER.

Fig. 7.



lining of the producer for motor vehicle work is a very important subject and one to which the author devoted much time, the experience gained with stationary plants not being of much use in this connection. In stationary practice, it is no uncommon thing to use linings 6 in. thick, a layer of sand 2 in. or more in thickness being interposed between the lining and the metal case of the producer.

To fit linings of this thickness was obviously an impossibility for vehicle work; the weight and size of the producer would have been prohibitive, and the cost of renewal not an inconsiderable item. A very thick refractory lining is equivalent to a thick metal bush or bearing on a shaft; long before it is worn through, it is worn too much to be workable. The author, therefore, adopted a comparatively thin lining—1½ in. thick—and found this quite satisfactory, and, owing doubtless to the comparatively rapid passage of heat through this small thickness, its life was far longer in proportion than the usual thick lining. In order not to lose the heat conducted through the lining, the author jacketed the outside of the producer casing with another case, leaving an annular space between. This will be clearly seen from Figs. 3 and 4. All the air entering the producer passes through this annular space, and the heat conveyed through the lining, which would otherwise be lost, is utilised, and appreciably helps the flexibility of the producer. In stationary practice, cold air is drawn directly into the vaporiser or fire without any preheating, and to some extent negatives the effect of the thick refractory lining.

Actually, the use of the refractory lining is to prevent the rapid burning out of the metal casing of the producer. The author tried, for vehicle work, jacketing the producer with water, using a thin refractory lining as already indicated, and thus obtaining a large supply of steam, if necessary, under slight pressure. For this purpose, such a form of construction was found to be useless, as there was no method of controlling the amount of heat passing to the water, and, therefore, the steam supply was erratic, as it naturally depended on the pressure in the vaporiser jacket, and not on the requirements of the engine.

Even the weight of the thin lining used was considerable, and the author tried other material than the standard firebrick composition to see if this weight could not be lessened to some extent while retaining a melting-point high enough to withstand the work. The melting-point of the best firebricks are as follows:—

	Deg. C.
Alumina	2,100
Magnesia	2,720
Magnesite	2,165

The melting temperature of these is much above any temperature which should be reached in a producer if working correctly, and in this respect these materials are satisfactory, but the specific gravity ranges from 2 to 2·2 and the weight per cubic foot from 120 lb. to 137 lb.

This led the author to try a lining having a diatomitic base. The melting-point is comparatively low, but the weight per cubic foot is only 43·5 lb. and the specific gravity 0·7. It by no means follows that the lining with the highest melting-point stands up longest in work, but it is quite likely that in ordinary producer practice, where clinkers are allowed to form and heavy bars have to be used to detach fused masses from the refractory linings, a diatomitic lining would not last. In the author's system of working where no clinkers form, and no poking is required, the lining stands well and effects a most remarkable saving in weight. The method of regulating the steam supply, which maintains the fire temperature relatively constant, prevents any danger of melting the lining, the correct working temperature being well below the melting-point of the lining.

The lining can either be fitted in the form of curved slabs set in fireclay, or it can be fitted in one piece in the form of a cylinder moulded and baked to the correct dimensions. This is the most satisfactory manner, the linings being purchaseable for a few shillings each, and capable of being fitted in a few minutes without any need of bedding in with fireclay or similar cement. The life of the lining in normal work should average about twelve months.

Weight of Producer.—The plant, shown in Figs. 8 and 9, on this page, which has a grate 12 in. diameter, equivalent to 50 h.p., weighs, with its connections, approximately 2·75 cwt., corresponding to a weight of 6 lb. per horse-power, though no attempt was made to reduce weight. Retaining cast-iron as a cheap and suitable material, the weight of similar powered plants, as shown in Figs. 3 and 4, can be safely reduced to 224 lb. or 4·5 lb. per horse power. If pressed steel were adopted in lieu of cast-iron, and aluminium for the blower casing, fuel pipe, &c., the weight could be reduced to under 200 lb. In any case, taking the weight of 6 lb. per horse-power, the total weight is so little in proportion to the vehicle weight, that it is really negligible. For larger plants, the weight per horse-power can be much reduced, but for vehicle work a 50-h.p. plant is about the maximum likely to be fitted, so that 4·5 lb. per horse-power can be taken as a maximum figure. It is possible that at no distant date a very large plant will be at work, weighing under 1¼ lb. per horse-power.

Determination of the Size of the Producer for Motor Vehicle Work.—The size of a producer is regulated by the consumption of fuel for any given grate area. In stationary producer practice, a consumption of 10 lb. per square foot per hour is a usual figure. Assuming that a 50-h.p. producer is required, and the consumption of fuel (anthracite) is taken at 1·2 lb. per horse-power, it will readily be seen that a producer with the necessary grate area could not be accommodated on a vehicle without great loss in carrying capacity. In the producers built on the author's system, a consumption of 80 lb. per square foot of grate area per hour is possible. To deal with the necessary fuel consumption in this case, a grate diameter of approximately 12 in. is required, and this gives 2 sq. in. per horse-power. This factor can be used for producers between 20-h.p. and 80 h.p. The range of any given size is fairly wide, but if the producer is much too large for an engine, trouble will be experienced on light loads, such as when the engine is running light at slow speed. The suction through the producer is then insufficient to keep the fire at the right temperature, and if the engine is suddenly speeded up after running slowly for some minutes, the producer may not respond, and the engine will need careful nursing for 2 minutes or 3 minutes to get the fire hot again. It is really quicker when this occurs to blow up the producer as when starting up, as 30 seconds to 40 seconds blowing will freshen up the fire sufficiently.

On a motor vehicle the engine is very seldom working up to its full power, so that the producer is generally working well within its limits. If the engine when running light is kept at a fair speed, say, 300 r.p.m., no trouble will be experienced if the producer is proportionate to the size of the engine. For short periods, the engine can be set to just turn over, and it is possible to get a much slower running speed on gas than on petrol, but this must not be maintained. For vehicle stops of less than 10 minutes, it is not worth while to stop the engine, as the cost of fuel is negligible, but for stops of longer duration than this, the engine should be stopped, as it can be re-started, even after a stoppage of some hours, in 3 minutes.

Position of the Producer on the Vehicle.—The position which the producer is to occupy on a vehicle is regulated first by the size and weight. With some producers there is no option; they cannot be put in the most advantageous position, and some part of the useful space on the vehicle must be sacrificed, and access can only be obtained or attention given to the producer by stopping the vehicle. As it is now possible to reduce the size and weight of the producer plant to the figures given by the author, it is not necessary to encroach on any useful space or the driver's accommodation, and the producer can be fitted in the position shown in Figs. 8 and 9, on this page, which is generally vacant, and in the few cases where the driver's seat is placed on one side of the bonnet, the producer could be fitted on the other.

The plant will then be under the constant observation of the driver, and although practically no attention is required after once starting, he will be able to see that the functions of the producer are being carried out. If necessary, the producer could be put under the bonnet.

The canopy over the driver's head will accommodate a fuel hopper capable of holding enough fuel for a day's run, and here again no useful space is occupied. In fact, unless the fuel hopper is pointed out, it is not noticeable.

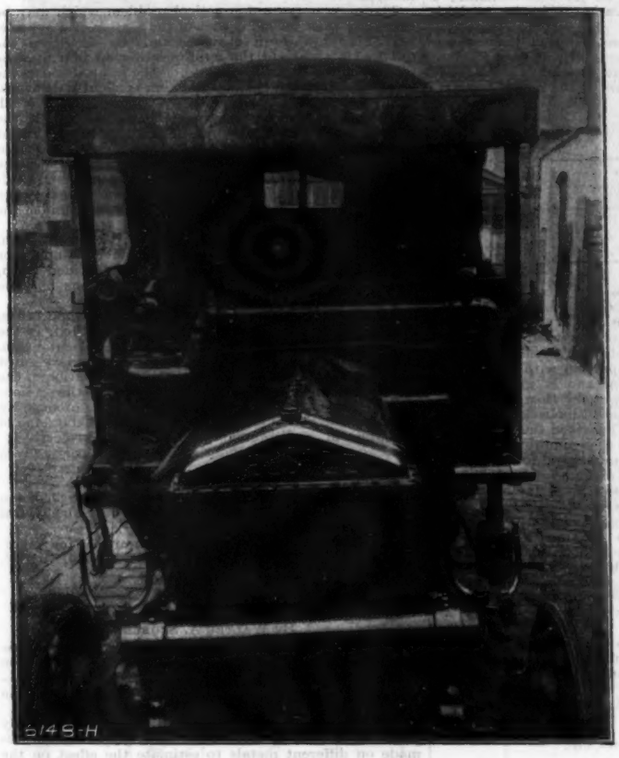


FIG. 8.

FIG. 9

FIGS. 8 AND 9. SMITH PRODUCER FITTED TO A LORRY.

The water for the producer can be carried in the space usually occupied by the petrol tank under the driver's seat or in the part of the canopy not occupied by the fuel hopper. The pipe conveying the fuel to the producer presents no obstacle to the driver's view, and has a slot running down its length by which he can constantly watch the feed of fuel. Little or no heat is noticeable from the producer when running. The asphyxiation of the drivers, which was often prophesied, has not yet occurred, and if it is remembered that while running there can only be leakage of air into the plant, not leakage of gas from the plant, it will be appreciated that no danger can arise. By carrying the discharge pipe above the canopy, all fumes, gas, &c., when blowing up or standing, can be conducted above the top of the vehicle and dissipated without annoyance. For public service work, this is the only possible position for the producer in the author's opinion, as it leaves the whole of the body entirely free, and there is no possibility of any discomfort being caused to passengers, as nothing in connection with the producer need be behind the dashboard.

(To be continued.)

STRESS DISTRIBUTION IN ENGINEERING MATERIALS.

Stress Distribution in Engineering Materials.—Report of the Committee of the British Association, consisting of Professor J. PERRY *(Chairman)*, Professors E. G. COKER *and* J. E. PETAVEL *(Secretaries)*, Dr. A. BARR, Dr. CHAS. CHREE, Mr. GILBERT COOK, Professor W. E. DALBY, Sir J. A. EWING, Professor L. N. G. FILON, Messrs. A. R. FULTON *and* J. J. GUEST, Dr. B. P. HAIGH, Professors J. B. HENDERSON, F. C. LEA, *and* A. E. H. LOVE, Dr. W. MASON, Professor A. F. ROBERTSON, Dr. F. ROGERS, Mr. W. A. SCOBLE, Dr. T. E. STANTON, Mr. C. E. STROMEYER, *and* Mr. J. S. WILSON, ***to report on certain of the more complex Stress Distributions in Engineering Materials.***

(Concluded from page 27.)

NOTE ON THE PRINCIPLE OF DYNAMICAL SIMILARITY APPLIED TO DEFORMABLE ELASTIC STRUCTURES.

By Professor L. N. G. FILON, F.R.S.

1. *General Case of Structure of Finite Thickness.*—Consider any deformable structure subjected to strain. Let a mechanical model of this structure be made accurately to scale, but of different material. We will investigate the relations which have to be satisfied by the elastic constants and the stresses applied if the deformations of the original system and of the model are to be geometrically similar. Let k be the ratio of similarity of the model and the original, so that if l be any length in the original, kl is the corresponding length in the model.

If x, y, z are the co-ordinates of any point of the original (kx, ky, kz) are the co-ordinates of the corresponding point of the model.

If (u, v, w) are the displacements at (x, y, z), (ku, kv, kw) are the displacements at (kx, ky, kz).

The *strains*,

$$e_x = \frac{\partial u}{\partial x}, \quad e_y = \frac{\partial v}{\partial y}, \quad e_z = \frac{\partial w}{\partial z}.$$

$$\sigma_{yz} = \frac{\partial v}{\partial z} + \frac{\partial w}{\partial y}, \quad \sigma_{zx} = \frac{\partial w}{\partial x} + \frac{\partial u}{\partial z}, \quad \sigma_{xy} = \frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}$$

are identical in the model and original.

The *stresses* are given by

$$\widehat{xx} = \lambda\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}\right) + 2\mu\frac{\partial u}{\partial x};$$

and two similar equations

$$\widehat{yz} = \mu\left(\frac{\partial v}{\partial z} + \frac{\partial w}{\partial y}\right);$$

and two similar equations, λ and μ, being the elastic constants of Lamé.

Thus, in general, for dynamical similarity, all the elastic constants have to be altered in the same ratio q, and the applied stresses must be altered also in the ratio q.

2. *Framework of Thin Rods.*—In the case of *thin* rods forming part of a plane framework under stress in its own plane, we have, if T be the total tension and M the bending moment at any point of a rod, and T′, M′ the corresponding quantities in the model,

$$T = E\,\Delta\,e;$$
$$T' = E'\,\Delta'\,e'.$$

when e, e' are the longitudinal strains of the rod in the full size and model, respectively.

E, E′ are the Young's moduli, Δ Δ' the cross-sections of the rods.

Now $e = e'$ by geometrical similarity.

Hence $$T : T' = E\,\Delta : E'\,\Delta' \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Further $$M = \frac{E\,I}{R}$$

where I is the moment of inertia of the cross-section of the rod about its neutral axis and R is the radius of curvature of the rod.

Similarly $$M' = \frac{E'\,I'}{R'}$$

where clearly $R' = k\,R$ by geometrical similarity. Also, let p be the ratio of forces (*not* stresses) in the model and full size. Then $M' = M\,p\,k$, *i.e.*,

$$E'\,I'/R' = p\,k\,(E\,I\,/\,R),$$

and $$E'\,I'/E\,I = p\,k^2 \quad . \quad . \quad . \quad (2)$$

But from (1) since $T' = p\,T$

$$\frac{E'\,\Delta'}{E\,\Delta} = p. \quad . \quad . \quad . \quad . \quad (3)$$

From (2) and (3) by division

$$\frac{I'\,/\,\Delta'}{I/\Delta} = k^2 \quad . \quad . \quad . \quad . \quad (4)$$

Let K be the swing radius of the cross-section of any rod in the full size, and K′ in the model.

Then $$I = K^2\,\Delta$$
$$I' = (K')^2\,\Delta'$$

(4) then gives $(K')^2\,/\,K^2 = k^2$

or $$K' = k\,K \quad . \quad . \quad . \quad . \quad (5)$$

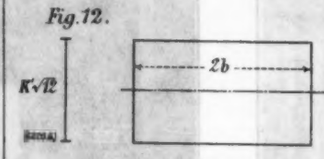
That is, although the cross-sections need not be geometrically similar (the rods being *thin*), the radii of gyration of the cross-sections must be in the ratio of *geometrical* similarity k.

This condition being once satisfied, equation (3) shows that the moduli E′ Δ', E Δ for the rod as a whole, must be in the ratio of *dynamical* similarity p, *i.e.*, in the ratio of the applied forces.

Now k will usually have to be fixed beforehand; k being known, the radius of gyration K′ in the model is fixed.

The materials of the model are also usually not at our choice. Thus E′ is fixed. But Δ' can be varied within large limits, and this without altering k. An easy example of this is when the bars of the model are rectangular in section.

Fig. 12.



The height of the cross-section $= K'\sqrt{12}$ and is therefore fixed. But the breadth $2b$ is at our disposal and can be varied, so that Δ' satisfies equation (3).

An important particular case occurs when certain rods or ties of the full size are practically unyielding or inextensible, at any rate, in comparison with the others. In this case E is infinitely great and E′ must also be infinitely great. All that is necessary then is to make the corresponding bars of the model likewise unyielding or inextensible in comparison. Provided this is done we need only trouble to satisfy the conditions for the "yielding" or soft parts of the model and full size.

If the model and full size are made up of *two* kinds of material only—a "yielding" and an "unyielding"—it will usually be convenient to satisfy equation (3) by adjusting p, the ratio of dynamical similarity, that is, by applying suitable loads to the model instead of altering the cross-sections to the right ratio.

3. *Safety Conditions for the Model.*—The question of breaking stress on the model is one of fundamental importance. For we have to be careful that the stresses imposed in conserving similarity shall not be so great as to cause the model to collapse.

We have, y and y' being the distances from the neutral axes of the outermost fibres in full size and model respectively, the greatest stresses as follows:—

$$E s + \frac{E\,y}{R} \quad \text{(full size)};$$

$$E' s' + \frac{E'\,y'}{R} \quad \text{(model)};$$

(numerically positive values being taken for each quantity).

Now $s' = s$, $R' = k\,R$; but y' is not equal to $k\,y$ in general. As, however, $K' = k\,K$, in the case of rectangular bars $y' = k\,y$ accurately, and it is not unreasonable to suppose that y' will generally be of the order $k\,y$. (Note for *similar* sections $y' = k\,y$ also.) Thus we may take the case of rectangular bars as fairly typical.

We have then $$\frac{y}{R} = \frac{y'}{R'}$$

and greatest stress in model: greatest stress in full size $= E' : E$. That is: greatest *strain* in model $=$ greatest *strain* in full size.

Hence the greatest strain to which the material of the full size is subjected in the case considered must not break down the material of the model.

If the model is made of much more yielding material than the full size, the material of the model will, as a rule, stand a much greater strain than that which would break material of the corresponding full-sized member.

Xylonite is a much more yielding material than wood. So that if the full-size spar is of wood and the model of xylonite, the conclusions of the last paragraph hold good. Loads on the xylonite model will still usually be well within the safety limit, even when the corresponding loads on the full-size wooden member exceed the safety limit, a point of great value in investigating dangerous stresses.

THE SOAP FILM METHOD OF STRESS ESTIMATION.

By A. A. GRIFFITHS.

The use of soap films in the determination of elastic stresses and strains depends on the mathematical similarity between certain forms of the general equations of elasticity, and the equation of the surface of a soap film slightly displaced from a plane.

The latter equation may be taken to be:

$$\frac{\partial^2 z}{\partial x^2} + \frac{\partial^2 z}{\partial y^2} + \frac{p}{2\,s} = 0$$

where the plane is that of x, y, p is the pressure difference between the two sides of the film, and s is the surface tension. Any two-dimensional elastic problem in which the dilation, or the sum of the principal stresses, is a known function of x and y may, by known mathematical methods, be made to depend on the solution of an equation of this type. This is the most general form of elastic problem which can be solved directly by means of soap films.

The solution is obtained by forming a film, which satisfies the conditions of the problem, and taking the required measurements from it by means of special appliances. The most useful of these are:—

(*a*) The spherometer, which is a needle, moistened with soap solution, which can be moved at will in any desired plane parallel to the plane of x, y. This is caused to touch the film at a series of points, whose positions are recorded by a simple copying mechanism. In this way a complete contour map of the film surface may be obtained.

(*b*) The auto-collimator, which measures the slope of the film at any desired point by an optical reflection method.

The most important practical problem which may be solved by this method is that of the torsion of a cylinder or beam of uniform cross-section. In this case the dilation is zero, and the appropriate soap film may be formed on a hole, in a flatplate, of the same shape as the cross-section of the beam. The film is slightly displaced from the plane of the plate by maintaining a small excess of pressure on one side of it. The slope of the film at any point is proportional to the stress at that point, the direction of the contour lines is the direction of the stress, and the volume between the film and the plane of the plate is proportional to the torsional stiffness of the beam. The constants of proportionality are obtained by comparison with a circular film under the same pressure difference.

Sections of any shape whatever may be dealt with, but in the case of hollow beams the inner boundary or boundaries must be parallel to, but not coincident with, the outer one. The proper relative positions may be found by measuring auxiliary soap films.

A further problem of considerable practical importance, which may be solved by the soap film method, is the determination of the shearing stresses in a bent beam. In this case, the hole representing the boundary must be cut in a curved plate, the shape of the elevation of the edge being calculated from the dimensions of the section. This film is not blown up. The components of shearing stress are calculated from the components of the slope of the film, in the directions $o\,x$ and $o\,y$ respectively. The twist of the beam, under a load applied at any given point, may also be found.

The following papers deal with the subject:—

1. "The Use of Soap Films in Solving Torsion Problems." Proceedings of Institute of Mechanical Engineers, December 14, 1917.

2. Reports of the Advisory Committee for Aeronautics. R. and M. 393, R. and M. 334, T. 1040, T. 1076, T. 1275.

ECCENTRIC LOADING IN TENSION AND COMPRESSION TESTS.

By WALTER A. SCOBLE.

The earlier tests were made to determine the degree of variation of stress across the section of a specimen subjected to tension or compression. Different arrangements for the application of the load were tried, and the specimens were prepared from various materials.

The effect of the eccentric loading was surprisingly pronounced, and a further series of experiments was made on different metals to estimate the effect on the test results of the unequal stress distribution across the section of the specimen.

A distinction must be drawn between the two series of tests. The first set represents conditions which are realised in practical testing, but for the second series the load was occasionally purposely made eccentric to yield evidence of the effect of bending on the behaviour of the metal under test.

The extensometer used (Fig. 13) consisted of two independent clamps attached to the specimen by pointed screws. The lower clamp carries four self-contained, double-lever, strain-measuring units. A scale division represents about three-millionths of an inch change of length of the specimen, but less sensitive elements are used for materials which have low values of E. The test length is usually 1·5 in.

Three measurements are sufficient to allow the strain distribution across the section of the test-piece to be calculated, but the fourth introduces no further complication and allows a useful check to be made, or avoids the scrapping of a series of readings if one element deflects beyond the limit of its scale.

Typical plottings of the four measurements against the loads are given in Fig. 14 as an example of very eccentric loading, and in Fig. 15 to show the best result realised in practice.

Variation of Strain across the Section of a Test-piece.—The first results are collected to indicate the variation of the strain across the section of a specimen. The usual precautions were observed for the type of test considered. The strain distribution usually alters somewhat with the load, so the figures tabulated have been taken for the region of the elastic limit, or, when the load was not taken so high as this, for the greatest load applied.

The results show that the variation of strain, and therefore of stress, across the section of a test-piece is usually appreciable and is sometimes of considerable magnitude.

For plain ended tension specimens of mild steel held

by wedge grips, the maximum exceeds the mean strain by an average value of 16 per cent., reaching 24·2 per cent. in one case. For cast steel, similarly gripped, the corresponding figures are 12·8 per cent. and 16 per cent. The serrated wedges appear to bite more deeply into annealed mild steel, and the figures rise to 40·8 per cent. and 62 per cent. This inequality is so great that it is rather startling, but it is reduced for similar specimens to 9·9 per cent. and 16·1 per cent. by the adoption of screwed ends. There is no evidence of a corresponding inaccuracy due to wedge grips after a high carbon steel is annealed.

Rod brass and aluminium bronze gave results which are in general agreement with those summarised above,

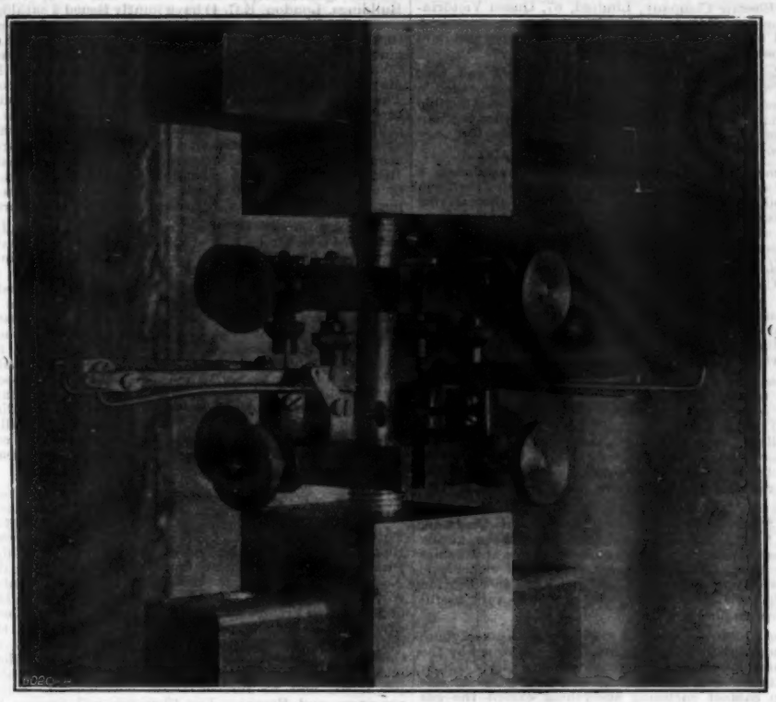
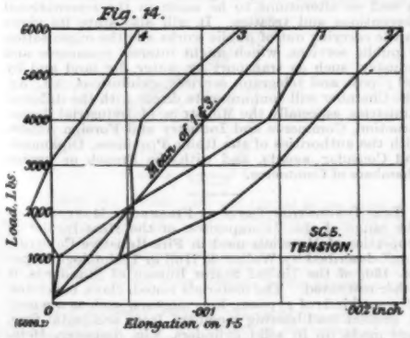


FIG. 13. EXTENSOMETER.



but in one case the bronze with screwed ends showed maximum strains 36 per cent. and 39 per cent. greater than the mean. It appears probable that here the inequality is due rather to lack of homogeneity of the material rather than to eccentricity of loading, and the same explanation may be given to account for the variations with the accurately constructed Robertson loading device used in some of the experiments.

The Effect of Eccentric Loading on the Elastic Limit and Yield Point.—Eccentric loading would be of no importance if it did not affect the test results. The elastic-limit, yield-point, and maximum stresses should all be considered to determine the effect upon them. It may be noted that if there is appreciable yield before fracture it is to be expected that the stress on a section of a tension or compression specimen is equalised, and that the mean maximum stress is not appreciably affected by a probable amount of eccentricity in the loading.

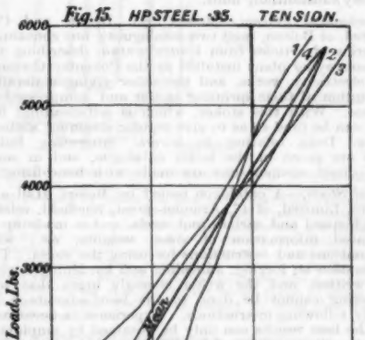
The test results are tabulated on this page, according to the material, to compare the stresses at the elastic-limit, yield-point, and maximum load. The elastic-limit stress, calculated by dividing the load by the area of the cross-section, is also corrected in the ratio of the maximum to the mean strain.

In order to judge whether the stresses should be corrected in the ratio of the variation of strain, the values at the elastic limit for the same material can be compared amongst themselves, and with the yield-point stresses.

The adjustment is not justified for unannealed mild steel. In the case of S2.2 the elastic-limit and yield-point coincided. The correction makes the elastic-limit greater than the maximum stress. For Sc. 5 and HP. 28 the corrected E.L. stresses are much greater than those at the corresponding yields.

There is no doubt that inaccurate loading lowers the mean elastic-limit stress in the case of annealed mild steels, and that its true value varies somewhat. The two samples SC. 4 show approximately the same stress distribution, but the E.L. stresses are 8·55 tons and 9·32 tons per square inch before correction. BA. 1, 6, and 7 afford an even better example because the higher E.L. accompanies the lower Y.P. stress.

Evidently the measured E.L. stresses need some correction to give true values, but it seems that that indicated by the strain distribution is too drastic if the eccentricity of loading be large, *e.g.*, SC steel. Of the BA specimens 7 and 8 agree fairly well after correction with each other and with the yield stresses, but for 6 the value is still low. The S2 steel shows similar inequalities, 3 and 5 are over-corrected, but for 6 and 7 the results are fairly good.



It is desirable to remark that too close agreement cannot be expected between values for stresses at the elastic-limit, not at yield when the stress is unequally distributed. In general, the stress-strain curve does not diverge greatly from a straight line at first, and, since small errors of observation arise, it is not easy exactly to locate the required point.

Tension Tests. Solid Specimens.

No.	Material.	Condition.	Method of Loading.	Maximum Strain, / Mean Strain.
S2. 2	Mild steel ..	Not annealed	Wedge grips	1·242
SC. 1	Mild steel ..	Not annealed	Wedge grips	1·214
SC. 5	Mild steel ..	Not annealed	Wedge grips	1·170
HP. 28	38-ton steel	Not annealed	Wedge grips	1·158
HP. 35	38-ton steel	Not annealed	Wedge grips	1·016
S.1. 4	Cast steel ..	Not annealed	Wedge grips	1·086
S.1. 5	Cast steel ..	Not annealed	Wedge grips	1·160
S.1. 10	Cast steel ..	Not annealed	Wedge grips	1·137
SC.4. 1	Mild steel ..	Annealed ..	Wedge grips	1·620
SC.4. 2	Mild steel ..	Annealed ..	Wedge grips	1·585
BA1. 6	Mild steel ..	Annealed ..	Wedge grips	1·104
BA1. 7	Mild steel ..	Annealed ..	Wedge grips	1·273
S2. 3	Mild steel ..	Annealed ..	Wedge grips	1·328
S2. 6	Mild steel ..	Annealed ..	Wedge grips	1·415
S2. 7	Mild steel ..	Annealed ..	Wedge grips	1·533
SC2.	Mild steel ..	Annealed ..	Screwed ends	1·161
BA1. 1	Mild steel ..	Annealed ..	Screwed ends	1·068
BA1. 8	Mild steel ..	Annealed ..	Screwed ends	1·106
S2. 5	Mild steel ..	Annealed ..	Screwed ends	1·062
S1. 2	Cast steel ..	Annealed ..	Wedge grips	1·018
S1. 7	Cast steel ..	Annealed ..	Wedge grips	1·162
BC. 1	Brass rod ..	—	Screwed ends	1·080
BC. 2	Brass rod ..	—	Wedge grips	1·201
AB. A1	Aluminium bronze	As cast ..	Screwed ends	1·127
AB. A.2	Aluminium bronze	As cast ..	Screwed ends	1·100
AB. B.1	Aluminium bronze	As cast ..	Screwed ends	1·360
AB. B.2	Aluminium bronze	As cast ..	Screwed ends	1·390
100 A.2	Aluminium alloy	As cast ..	Robertson's ball loading	1·052
100 A.3	Aluminium alloy	As cast ..	Robertson's ball loading	1·140
100 A.4	Aluminium alloy	As cast ..	Robertson's ball loading	1·077

Tension Tests of Tubes.

Specimen.	Method of Loading.	Maximum Strain, / Mean Strain.
Steel tube, ¾-in., 22g ..	Coned tube grips ..	1·156
Steel tube, ¾-in., 22g ..	Coned tube grips ..	1·155
Aluminium, ¾-in., 16g ..	Coned tube grips ..	1·187
Aluminium, ¾-in., 16g ..	Coned tube grips ..	1·090
Aluminium, ¾-in., 16g ..	Ends flattened, wedge grips	1·180
Steel streamline .. .. 1¼ × ⅝ × 20g	Ends flattened, wedge grips	1·454
Aluminium alloy, ¾-in. ..	Coned tube grips ..	1·055

Compression Tests.

Material.	Form.	Method of Loading.	Maximum Strain, / Mean Strain.
Spruce ..	Tube o.d. 1·36-in. i.d. 0·75-in.	Through ball on steel cap	1·205
Aluminium alloy	Solid, 1·44-in. diameter	Through ball on turning centre	1·058
Aluminium alloy	Solid, 1·35-in. diameter	Through ball on steel cap	1·706
Aluminium alloy	Solid, 1·35-in. diameter	Through ball on steel cap	1·110
Mild steel ..	Solid, annealed 0·78-in. diameter	Through ball on turning centre	1·142
Aluminium alloy	Solid, 1·07-in. diameter	Through ball on turning centre	1·095
Aluminium alloy	Solid, 0·70-in. diameter	Through ball on turning centre	1·352
Steel ..	Streamline tube	Through ball on steel cap	1·362

Cast steel as supplied in the bar gives results which are not improved by the suggested correction, but the annealed specimens need it.

The values for aluminium and the bronzes are in no better agreement after the adjustment.

Only two specimens of brass rod are included, but these show the best agreement of all between the corrected E.L. stresses.

Unfortunately, it is not possible to draw many general conclusions from the data available. Only in the cases of annealed steels and brass is the proposed correction of the elastic-limit stress, in the ratio of maximum to mean strain, at all justified, and then the factor is too large if the inaccuracy of loading is considered.

The degree of eccentric loading which is likely to arise in tension-testing has less effect on the yield-point stress than the differences which are found along the same bar, and, as was expected, there is no evidence of the maximum stress being affected.

Should the elastic-limit of a steel or the yield-point of other material be required, it is necessary to take precautions to ensure that the loading is accurate, and thus minimise the necessity for correction, which latter cannot be applied in any case with certainty.

EXPERIMENTS ON THE EFFECT OF ALTERATIONS OF TENSILE STRESS AT LOW FREQUENCIES ON THE ELASTIC PROPERTIES OF MILD STEEL.

By ANGUS R. FULTON, M.B.E., B.Sc., A.M.Inst.C.E., Temp. Major Royal Air Force.

The work was carried out in the Engineering Laboratory of University College, Dundee. It was directed to several points raised in the investigations into the theory

Results of Tests.

Specimen.	Maximum Strain, Mean Strain.	Elastic Limit Stress. Direct.	Elastic Limit Stress. Corrected.	Yield Stress.	Maximum Stress.
		tons, sq. in.	tons, sq. in.	tons, sq. in.	tons, sq. in.
Mild steel, not annealed.					
S2. 2	1·242	21·1	26·2	21·1	25·6
SC. 5	1·170	14·9	17·45	15·5	21·9
HP. 28	1·158	25·0	28·95	26·7	38·7
HP. 35	1·016	23·66	24·04	26·6	38·5
Mild steel annealed.					
SC. 2	1·161	11·16	12·97	12·5	20·6
SC. 2	4·40	4·56	20·1	11·9	20·75
SC. 4	1·620	8·55	13·85	12·65	—
SC. 4	1·585	9·32	14·78	14·05	20·8
BA1. 1	1·068	10·04	10·72	10·04	20·8
BA1. 6	1·104	14·31	15·83	17·55	23·6
BA1. 7	1·273	13·48	17·15	17·35	23·8
BA1. 8	1·106	15·24	16·86	17·17	24·0
S2. 3	1·328	9·06	12·03	10 07	20·9
S2. 5	1·062	10·03	10·66	10·30	22·0
S2. 6	1·415	8·52	12·05	12·49	21·9
S2. 7	1·533	7·41	11·35	11·73	21·7
Cast steel not annealed.					
S1. 4	1·086	18·14	19·7	26·3	51·5
S1. 5	1·160	23·5	27·2	23·5	51·8
S1. 10	1·137	20·44	23·22	24·0	53·0
Cast steel annealed.					
S1. 2	1·018	19·0	19·3	19·6	46·9
S1. 7	1·162	16·9	19·65	19·8	—
Steel tube, ¼-in.	1·156	15·6	18·03	—	44·1
Steel tube, ¼-in.	1·155	15·62	16·04	—	43·6
Aluminium tube	1·187	6·09	7·93	—	13·1
Aluminium tube	1·090	5·68	6·19	—	—
Aluminium tube	1·160	6·40	7·42	—	12·8
Cast.					
Aluminium, bronze A ..	1·127	13·10	14·75	—	40·4
Aluminium, bronze A ..	1·100	12·73	14·0	—	41·7
Aluminium, bronze B ..	1·36	4·46	6·06	—	30·7
Aluminium, bronze B ..	1·39	6·10	8·50	—	—
Rod brass, BC. 2 ..	1·261	9·64	12·15	—	34·4
Rod brass, BC. 1 ..	1·08	11·07	11·95	—	34·8

of failure due to repetitions of stress by Reynolds and Smith, Stanton and Bairstow, and others, which appeared to require further examination.

The points referred to are, briefly stated, as follows:—

1. The effect of the variation of tensile stress as distinguished from a variation of stress from tension to compression.

2. The variation of the maximum limit when combined with a fixed lower limit of range of stress.

3. The limiting range of stress and its relation to the maximum stress, its effect on the elastic properties of the material, and the connection between complete recovery and perfect elasticity.

4. Any indications given by the crystalline structure as to whether failure is likely to occur.

The testing machine was specially designed for the setting up of tensile stresses only by the late Professor T. C. Fidler, M.I.C.E., and was constructed in the Engineering Department of University College, Dundee. The load is applied by means of hydraulic pressure acting on the underside of a piston to which is attached through a spherical bearing joint the upper end of the test-piece, the lower end being similarly connected to a fixed cross-head. The number of alternations of pressure is capable of being varied from 10 per minute to 18 per minute.

A special feature of the machine is its ability to take test-pieces of the same dimensions as those ordinarily used in a Wicksted Machine with a length sufficiently great to allow of the use of a Ewing Extensometer.

The material used in the first test-piece was Siemens Martin steel, and under static load showed a yield stress of 15 tons per square inch and a maximum stress of 26·4 tons on the original section with an ultimate elongation of 32·8 per cent. on an 8-in. length. The later specimens, in order to fit in with the scheme of research framed by the Engineering Committee of the British Association on Complex Stresses, were of specially supplied dead mild steel (0·12 per cent. carbon), yield stress 15·5 tons per square inch, maximum stress 23·4 tons, and elongation 33·7 per cent.

In the series of tests, in which alternations of tensile stress only were given, it was found that:—

1. After ordinary yield is exceeded and permanent elongation has taken place, the limits of the proportionality of stress and strain are raised. The extent of this elongation for any maximum stress depends on whether the stress has been applied in one stage or with a sufficient number of repetitions at each of several stages.

2. The range of stress over which this proportionality is maintained is limited; once established it is independent of the number of cyclical repetitions to which it is subjected.

3. The range of stress may be again varied by further elongation, but to this there is a limit.

4. Failure under repetitions of tensile stress occurs by the movement of the crystals relatively to one another, consequent on the existing range of stress being exceeded, or during the transition period when one range is being changed to another.

5. Failure frequently originates by the range of stress, or even the maximum static stress of the material, being exceeded in parts of a section, and is due to mechanical flaws in the material or to non-axial loading.

CATALOGUES.

Electric Cables.—A very complete catalogue, giving full particulars of single and twin wires and cables, and flexible cables and cords, has been issued by the India-Rubber, Gutta Percha and Telegraph Works Company, Limited, of Silvertown, London, E. 16.

Lathe Tools, &c.—A special catalogue of tool holders, carriers, drill sockets, mandrels, taper gauges and self-centring chucks has been issued by Messrs. Jones and Shipman, Limited, of Leicester. All the tools are well finished and a full range of sizes of each kind is listed.

Electric Lantern.—A lantern for lighting streets and yards, is described in a special catalogue issued by the General Electric Company, Limited, 67, Queen Victoria-street, London, E.C. 4. It has improvements in ventilation and focussing and is also of moderate weight and good appearance.

Electric Cables.—Messrs. Siemens Brothers and Co., Limited, of Woolwich, London, S.E. 18, have issued a comprehensive catalogue of cables, bell wires, flexible wires, &c., with dimensions, resistances and other particulars given in the form of classified tables for easy reference.

Gas and Oil Engines.—A catalogue containing a reasoned statement favouring the use of coal in the form of gas, oil, coke, &c., instead of burning it directly for steam raising has been issued by Messrs. Crossley Brothers, Limited, of Manchester. A few particulars of gas plants and gas and oil engines are also given.

Rawhide Belts and Pinions.—The British Rawhide Belting Company, Limited, of Hythe-road, Willesden, London, N.W. 10, send catalogues of their rawhide pinions and blanks for both spur and bevel gearing. Particulars are also given of flat and round belting in all sizes ordinarily used. Suitable lacings and tools are also shown.

Concrete Blocks.—Machines for making concrete building blocks, including all the blocks required for ordinary work, are illustrated and described in a small catalogue to hand from Messrs. Phillips and Co., Limited, First Gallery, Coal Exchange, London, E.C. 3, who are agents for the makers, Messrs. R. H. Kirk and Co. The machines are hand-operated by unskilled labour, are very rapid in action, and are easily transported.

Electric Cables.—A catalogue of 56 pages issued by Messrs. Johnson and Phillips, Limited, of Charlton, London, S.E. 7, is practically filled with tables giving precise particulars of rubber insulated wires and cables made by them. The tables are printed in clear type under the various grade headings, and a full specification is given in each case. The catalogue will be very useful to electrical engineers.

Welding Outfits.—Complete outfits for oxy-acetylene welding and cutting are shown in a catalogue issued by the Davis-Bournonville Company, of Jersey City, U.S.A. The outfits are mounted on iron trucks, one of which has a lock-up cabinet enclosing everything except the gas cylinders. In another, an open truck with large wheels suitable for the road is used. The trucks, in all cases, are very substantially built.

Mechanical Stokers.—Messrs. Ed. Bennis and Co., Limited, of Bolton, send two catalogues; one containing a reprint of articles from ENGINEERING, describing the coal-conveying plant installed at the Coventry Corporation electricity works, and the other giving a detailed description of their sprinkler stoker and compressed air furnace. With this stoker, which is self-cleaning, fine slack can be fired so as to give regular steaming without smoke. Data relating to several interesting boiler trials are given in the latter catalogue, and in some cases direct comparisons are made with hand-firing.

Tool Steels.—A catalogue issued by Messrs. Hall and Pickles, Limited, of 47, Arundel-street, Sheffield, relates to high-speed and carbon tool steels, and is made up of tabulated information of sizes, weights, &c., with explanations and instructions for using the steels. The information on forging, annealing and hardening is very well written, and the writer strongly urges that tool tempering cannot be done to the best advantage by merely following instructions. Experience is necessary, and the best results can only be obtained by employing exceptionally careful and intelligent men.

Gravity Plant for Placing Concrete.—A catalogue from the Insley Manufacturing Company, Indianapolis, U.S.A., describes their plant for filling in concrete during the erection of buildings. The mixed concrete is hoisted up a lattice work steel shaft, placed vertically and guyed from the top, and thence tipped into a shoot, the lower end of which is easily adjustable to place the concrete properly. All the accessories are made to complete the plant. Messrs. Gaston, Limited, 20, Bishopsgate, E.C. 2, are the British representatives. Guyed and stiff leg derricks for general use are also made by the same makers, and are described in a special catalogue.

Alternating Current Generators.—A considerable range of alternating current generators, of the medium and slow-speed types, is described in a catalogue issued by Messrs. Bruce Peebles and Co., Limited, of Edinburgh. A full specification of the machines is given with lists of ratings for 50-cycle and 25-cycle alternators for all pressures from 200 volts to 6,600 volts, and the method of calculating the ratings of machines of other periodicities is explained. Tables of weights and dimensions in British and metric units are included, and a long list is given of public and private installations constructed by the firm.

Buildings, &c.—A number of outside staircases, labourers' cottages, bungalows, club rooms, churches, factories and sheds are shown in a catalogue which has reached us from Messrs. David Rowell and Co., Limited, of 14, Howick-place, London, S.W. 1. The whole of the materials and fittings are sent out ready for rapid erection, the various parts being each marked to facilitate the work of assembling. The cottages are one-storey structures with wood frames, floors, wall linings and doors, and although classed as temporary buildings, the materials and workmanship used in their construction is such that they should last for many years. Normally they are intended for export, or for home use for the accommodation of workmen engaged for a year or two on constructional work in some out-of-the-way place.

Magnetos.—A number of British magneto makers (the British Ignition Apparatus Association, of 8, Broams Buildings, London, E.C. 4) have jointly issued a catalogue containing illustrations and descriptive matter of types of these machines suitable for practically every class of engine. The firms included are the British L. M. Ericsson Company, the British Thomson-Houston Company, E.I.C. Magnetos, the M.L. Magneto Syndicate, North and Sons, Thomson-Bennett, and C. A. Vandervell. The introductory text contains some interesting facts and figures recalling our dependence on Germany for the supply of these machines on the outbreak of war. It is, however, hardly accurate to state that this dependence was due to "wasted British opportunity"; actually it was due to conditions of international trade which left British engineers no possibility of competing with the German manufacturers.

Grinding Machines.—The manufacture of grinding machines is now receiving attention from quite a number of British firms who are producing models containing substantial improvements in design and using only the very highest quality of material and workmanship in their construction. Among such firms must be included Messrs. Jones and Shipman, Limited, of Leicester, who have recently issued a catalogue describing a range of machines. Four sizes of universal grinders, five sizes of plain grinders, five internal grinders, two radial grinders and a number of spindles, heads and special attachments are included in the list. The radial machine can be used for internal or external spherical grinding, such, for example, as occurs on the surface of a ball or a ball race. The machines are of very substantial construction, with fine adjustments, and graduated scales are embodied in all the adjustable parts.

FRENCH CHAMBER OF COMMERCE FOR THE RHINE PROVINCES.—We read in *The Board of Trade Journa* that a French Chamber of Commerce in the Rhine Provinces is about to be formed. According to the Articles of Association, the headquarters of this Chamber will be in Paris, and the secretariat at Mayence. The object of this French Chamber of Commerce is to collect, exchange and distribute among merchants and the different commercial institutions in France and its Colonies, all useful information regarding the development of French industry and commerce in the Rhine provinces, and to further trade between the Rhine provinces and France. The Chamber will present its views on the modifications to be introduced in the commercial and industrial legislation of the two countries, as well as alterations to be made in the international conventions and treaties. It will also state its views on the carrying out of public works and the organisation of public services, which might interest commerce and industry, such as transport by water, by land and by rail; post and telegraph services, exhibitions, &c., &c. The Chamber will communicate direct with the different Ministries, especially the Ministries of Industrial Reconstruction, Commerce and Industry and Foreign Affairs, with the authorities of the Rhine Provinces, Diplomatic and Consular agents, and with the French or foreign Chambers of Commerce.

HEAT-INSULATION TESTS OF FIREPROOF MATERIALS.—The range of the "Comparison of the Heat-Insulating Properties of Materials used in Fire-Resistive Construction," described by Walter A. Hull in Technologic Paper No. 130, of the United States Bureau of Standards, is rather restricted. The materials tested, clays, concretes, different kinds of gypsum, lime mortars, such as are used to protect load-bearing members from accidental fires, were made up in solid cylinders, 8 in. diameter, 16 in. long, heated in a gas furnace up to 927 deg. C. and kept at that temperature for 2 hours. Thermocouples were embedded in the cylinders to determine the rate of heat penetration. In the dense clays (for tiles) the heat penetration was most rapid; it was slower in porous clays, but the highly-porous clays, prepared with sawdust, were not examined. Of the concrete mixtures those prepared with coarse gravel and with bituminous cinders containing a large proportion of combustible material heated through most rapidly. The penetration was slower with concrete made of bituminous cinders, trap rock and blast-furnace slag; limestone concrete showed the slowest penetration, possibly because the decarbonation of the limestone next to the exposed surface absorbed heat, and the calcium oxide produced by the expulsion of CO_2 was a better insulator than the original carbonate. In gypsum the dehydration caused a long temperature lag at about 105 deg. C., and the heat penetration was slower than in the concretes and clays, especially in the denser kinds of gypsum. Lime mortars behaved on the whole more satisfactorily than concretes. All the materials were weakened by the heat tests, the gravel concretes worst of all the concretes; this is ascribed to the inversion and expansion of the quartz at 575 deg. The general results are in agreement with previous researches, but are rather more favourable to porous clays, limestone concretes and dense gypsum than might have been expected.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Name, &c., of the Communicators are given in italics.

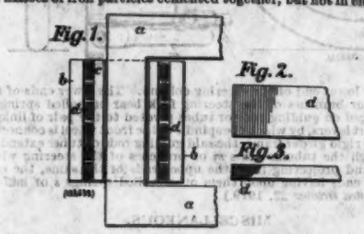
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

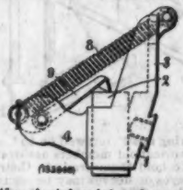
ELECTRICAL APPARATUS.

133,639. Siemens Brothers' Dynamo Works, Limited, Kennington, London, J. W. Howard, Stafford, and L. D. Morphew, Tillington, near Stafford. Electrical Transformers. (5 *Figs.*) May 27, 1919.—This invention relates more particularly to arrangements of the kind in which means are provided for largely increasing the normal reactance of the transformer. This increase is usually effected by providing magnetic shunts inserted between the primary and secondary windings of the transformer. According to this invention, the magnetic shunts are composed of bundles of insulated wires or of masses of iron particles cemented together, but not in electrical



contact to any appreciable extent. *a* is the ordinary laminated iron core of the transformer, *b* and *c* being respectively the primary and secondary windings thereof. *d*, *d*, represent reactance packets forming the magnetic shunt, and inserted between the windings and separated from each other by air gaps. As shown in Figs. 2 and 3, the magnetic shunt consists of bundles of iron wires insulated by an enamel coating and formed into a solid, rigid plate by the intermixture of a cementing material (as, for instance, the material for which "Bakelite" is the registered trade mark) and the application of pressure. (*Accepted October* 22, 1919.)

133,648. C. M. Owen, Abergavenny. Brush-Holders. (4 *Figs.*) June 16, 1919.—This invention relates to brush-holders for dynamo electric machines. According to the present invention, a brush-holder for a dynamo-electric machine comprises a frame 1 to accommodate the brush 2, and having an extension 3 towards the front and an extension 4 towards the rear. A lever 9 is pivoted to the extension 4, and is disposed so that during all or a part of its movement it is at an angle to, and above, a line

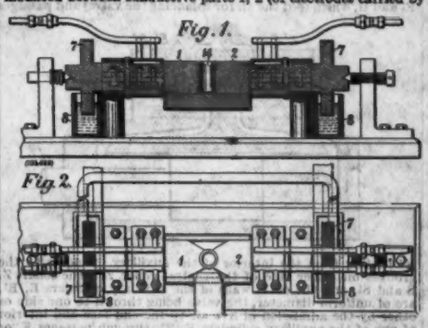


passing through the pivotal point and normal to the plane of movement of the brush and acting on the brush. A spring 8 is attached to the lever 9 and to the extension 3 of the frame. Preferably the lever 9 is pivoted at a point intermediate of its ends, the arms on the opposite sides of the pivotal point being disposed at an angle to each other, the arm on one side pressing on the brush and the spring being attached to the opposite arm. (*Sealed.*)

133,339. F. E. Berry, Hayes. Electrical Transformers. (1 *Fig.*) January 4, 1918.—For regulating the voltage of the current supplied from the secondary side of an electrical transformer, it has heretofore been common to provide the primary or secondary winding of the transformer with a number of tappings and to associate therewith a switch whereby the length of the active portion of the primary or secondary winding in circuit can be altered and the voltage of the secondary current correspondingly varied. The present invention has for object to enable a close regulation of the voltage supplied by a transformer to be obtained at any time within the range of variation of voltage which the transformer is designed to give. For this purpose

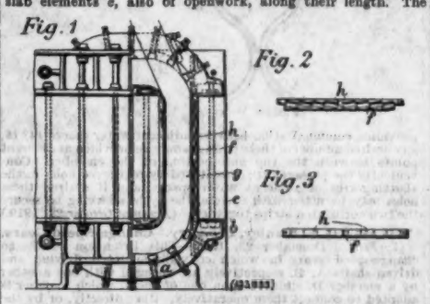
there are associated with a number of tappings on the primary or secondary winding of a main transformer T, and a main regulating switch S, whereby the active length of the primary or secondary winding in circuit can be altered and the voltage of the secondary circuit correspondingly varied, an auto-transformer *t* and a supplementary regulating switch S1, whereby there can be obtained by means of the auto-transformer a variable voltage within the limits of its design, by suitable operation of the two regulating switches S, S1, so that a much closer regulation of the voltage from the secondary winding of the main transformer is possible than with the simple tappings and regulating switch heretofore employed. For carrying out the invention, the main transformer tappings, the main regulating switch, the auto-transformer and the supplementary regulating switch are so arranged that any determined portion of the length of the winding of the auto-transformer can be connected in circuit with one or more of the sections of the main transformer winding with which it is associated, and with the supply main or conductors connected to such main transformer winding. (*Accepted October* 22, 1919.)

133,485. H. A. Kent, Bounds Green, London. Electric Furnaces. (3 *Figs.*) October 28, 1918.—The invention relates to electric furnaces of the type known as resister or crucible furnaces, and the object of the invention is to provide such electric furnaces in which the contact resistance is reduced and the electrical circuit between the mains is effected without wires, or other flexible connections, or conductors. In a furnace to which the invention is applied the resister or crucible 14 is mounted between conductive parts 1, 2 (or electrodes carried by



conductive parts) which are capable of movements of partial rotation in bearings or equivalent supports. According to the invention, the said conductive parts 1, 2, carry discs 7 or the equivalent dipping into mercury in receptacles 8 in connection with the electric supply mains, so that the resister or crucible and the said conductive parts, can be turned, to cast the metal. Means can be provided for cooling the said conductive parts, and good contact between the resister, or crucible, and the conductive parts or electrodes can be obtained by means of spring pressure. (*Accepted October* 22, 1919.)

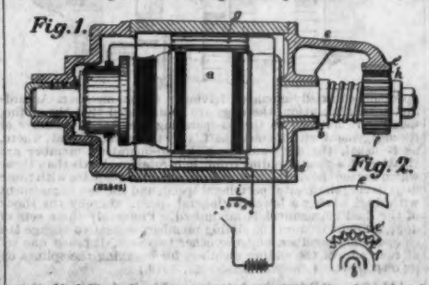
133,933. S. Z. De Ferranti, Hollinwood. Electric Transformers. (7 *Figs.*) August 27, 1918.—This invention relates to electric transformers and is directed to the retention of the coils thereof in proper position. The invention briefly consists in straight or circular wedging elements, adapted to assist in the location and containing of the transformer coils. In carrying this invention into effect as applied to shell transformers, open-work cage elements *a* embrace the heavy strip conductors. These caging elements comprise two similar arched openwork girder members, each having flanges *b*, which clamp against straight slab elements *c*, also of openwork, along their length. The



arched cage elements carry pinching studs which have insulated heads abutting against the conductor edges. These can be adjusted forward to pinch and definitely locate the conductor turns in position, and hold them against any stresses which may occur. The flat side portions of the conductors are held in position by the slab elements above referred to, aided by co-acting pairs of saw-tooth wedge-plate elements, according to the present invention. These wedge-plate elements comprise one stationary element *f* abutting against the conductors *g*, and two or more co-operating multiple surface wedge plates or strips *h*, each half the length, and drawn axially by bolts and nuts. (*Accepted October* 29, 1919.)

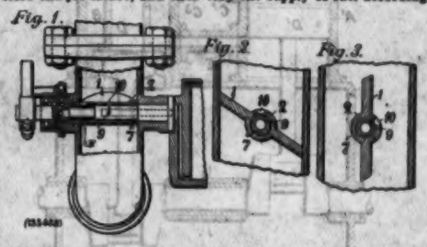
GAS ENGINES, PRODUCERS, HOLDERS, &c.

133,845. A. H. Midgley, Acton Vale, and C. A. Vandervell and Co., Limited, Acton Vale. Electric Engine Starters. (2 *Figs.*) December 21, 1918.—This invention relates to an improved electric starter of the screwed pinion type for internal combustion engines. According to the present invention, the



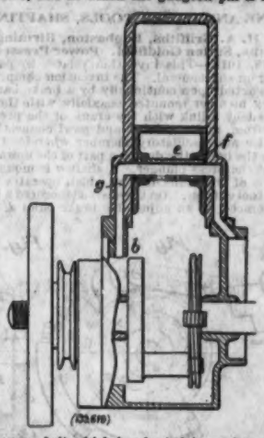
magnetic field produced by the field excitation coils of the electric motor is utilised for effecting the magnetic drag upon the pinion which is to be brought into engagement with the toothed flywheel or other toothed wheel associated with the engine to be started. The armature core *a* of a series electric motor is mounted direct on a steel shaft *b*, which is arranged to run in a brass bearing, whilst the end shield *d* of the motor is made of iron, and the yoke of the field magnet or the shield *d* is provided with a projecting-piece *e*, the end portion *e*1 of which is arranged to lie in the proximity of the pinion *f*, which is intended to be brought into engagement with the other member of the gear. It will thus be seen that in the arrangement according to the present invention, the magnetic circuit is as follows: The pole-pieces *g* of the field magnet, armature core *a*, armature shaft *b*, pinion *f* mounted thereon, a small gap *h* between the pinion *f* and the end portion *e*1, projecting-piece *e*, the yoke of the field magnet, and back to the poles *g* provided thereon. The motor may be used with a resistance *i* arranged in series therewith during the period that the two members of the gear are brought into engagement with each other, the said resistance being short-circuited or cut out after the two members of the gear have been brought into engagement with each other. (*Accepted October* 29, 1919.)

133,468. J. Walker, Birmingham. Carburettors. (9 *Figs.*) October 16, 1918.—This invention relates to carburettors of that type in which the main jet orifice 9 is formed in a hollow spindle or axial conduit 7, about which a sleeve 2, carried by or operated from the throttle valve and provided with an aperture 10, is adapted to turn so as more or less to open and close the jet orifice, and thus vary the supply of fuel according



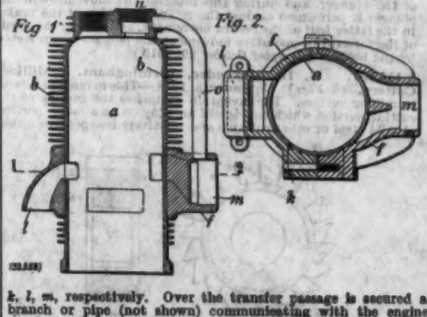
to the extent to which the said throttle is opened. According to the present invention, the regulating sleeve 2, upon the hollow spindle 7, is provided with the jet controlling aperture 10 situated within the induction pipe upon the engine side of the throttle valve 1, when the latter is closed, so that easy starting is obtainable, and no obstructions are present between the jet and the engine. (*Accepted October* 22, 1919.)

133,619. J. E. Smith, Gloucester. Internal-Combustion Engines. (1 *Fig.*) April 12, 1919.—This invention comprises an internal-combustion engine, in which air or explosive mixture from the crank-case *b* is adapted to pass axially through the gudgeon pin *e*, and in which the gudgeon pin is in the nature



of a tube or conduit which is adapted to register with conduits *g*, *f*, in the cylinder wall, these conduits being adapted to form a circulation system through which air is forced by the operation of the piston. The gudgeon rotates within bearing bosses *f* in the piston. (*Accepted October* 22, 1919.)

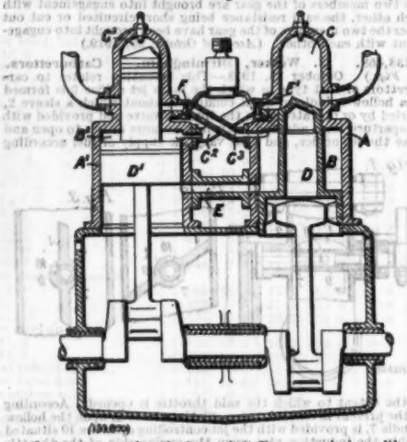
133,558. P. J. Goodman, Birmingham, and Veloce, Limited, Birmingham. Cylinders. (2 *Figs.*) January 7, 1919.—This invention relates to two-stroke internal-combustion engines as employed on motor cycles. The invention comprises the combination of a light steel cylinder *a* formed with the usual annular radiating fins *b*, and a two-part casing *f*, *f*, adapted to embrace the cylinder near its lower end, the casting being provided with the necessary fuel inlet, transfer and exhaust passages



k, *l*, *m*, respectively. Over the transfer passage is secured a branch or pipe (not shown) communicating with the engine crank-case. As usual, the fuel inlet passage *k* opens into the crank-case and is controlled by the lower portion of the piston. Between the relief valve pocket *a* at the upper end of the cylinder and the exhaust passage *m* in the casting, a pipe *o* is provided in the usual manner. The ends of this pipe are pushed tightly into apertures in the said parts during the assembling of the

cylinder and the above-mentioned casting. When the latter is in position on the cylinder it is impossible to detach the pipe. *Accepted October 22, 1919.*

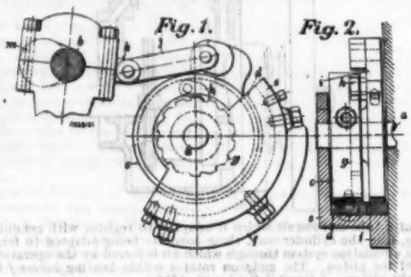
133,670. J. R. M. Stanfield, Cardiff. Internal-Combustion Engines. (2 *Figs.*) October 16, 1918.—This invention is for improvements in or relating to internal-combustion engines of the type wherein there are employed two differential cylinders A, A1, with differential pistons D, D1, working in them, dividing each into a working chamber C, C1, and a pump chamber B, B1, the pump chambers are cross-connected by conduits C2, C3, to the working chambers so that the pump chamber of one cylinder is in communication with the working chamber of the other cylinder



and *vice versa*, and a single conduit E communicates with both pump chambers, the cross-connecting conduits and the pump-chamber conduit being all controlled by their ends being covered and uncovered by the differential pistons. According to the present invention, an internal-combustion engine of the type described above has fuel nozzles F, F1, situated one in each cross-connecting conduit at those ends which communicate with the working chambers of the cylinders. (*Accepted October 29, 1919.*)

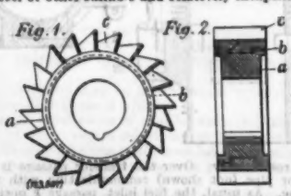
MACHINE AND OTHER TOOLS, SHAFTING, &c.

133,819. H. A. Griffiths, Edgbaston, Birmingham, and R. H. Griffiths, Sutton Goldfield. Power Presses. (2 *Figs.*) November 15, 1918.—This invention relates to power presses for operating on sheet metal. The invention comprises a brake disc which is acted upon continually by a brake band or block, an oscillatory member mounted coaxially with the brake disc and connected by a link with the crank of the press or a part driven therefrom, and a ratchet and pawl connection between the brake disc and oscillatory member whereby the latter is connected to the brake disc during a part of the upward or return movement of the press plunger. A shaft *a* is mounted parallel with the axis of the crankshaft *m* which operates the plunger carrying the tool or tools. On the shaft *a* is secured a brake disc *c*, which is embraced by an adjustable brake band *d*. The brake



band is carried in a housing *e*, which also carries the shaft *a* and is adapted by means of a flange *f* for attachment to the frame of the machine. Secured to the brake disc *c* is a ratchet *g*, and coacting with the ratchet is a pawl *h* carried on one face of a disc *i*, which can oscillate on the shaft *a*. This disc is connected by a link *j* with a lug *k*, on the plunger-connecting rod, the lug being situated on the end of the rod which embraces the crank *b*. The arrangement of the parts is preferably such that the ratchet is in operation only during the initial half of the return movement of the plunger, and during this interval the movement of the plunger is performed against the retarding action of the brake. In the latter half of the return movement, and during the whole of the forward or operative movement the plunger is unaffected by the brake. (*Accepted October 29, 1919.*)

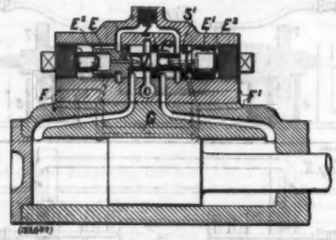
133,507. G. H. Alexander, Birmingham. Milling Cutters. (6 *Figs.*) November 8, 1918.—This invention relates to milling cutters. The invention comprises the casting of the cutting portion which consists of an alloy on to a main portion of mild steel or other suitable and relatively inexpensive metal.



In one manner of applying the invention to the production of milling cutters having cutting portions of zirconium alloy (*e.g.*, an alloy consisting essentially of zirconium and nickel, a mild steel disc or cylindrical blank *a* is formed with a peripheral groove *b*, and also, if desired, with transverse grooves. This blank is placed in the centre of a mould which is shaped around its periphery to the form of the required milling cutter, and in the intervening space is poured the alloy. The tool comprising the central blank *a* and the surrounding toothed annulus *c* of the alloy is finished by grinding operations. It is found that a satisfactory union of the two metal portions can be effected in the manner above described and in consequence only a relatively small amount of the expensive metal is required in the production of the tool. (*Accepted October 22, 1919.*)

MINING, METALLURGY, AND METAL WORKING.

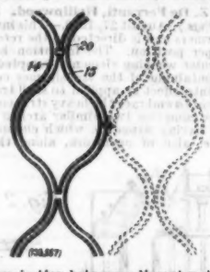
133,642. G. H. T. Rayner, Sheffield. Rock Drills. (1 *Fig.*) June 5, 1919.—A rock drill valve and valve gear of the type in which the valve works over fixed end pistons is characterised by passages E2 in the walls of the auxiliary cylinders E, E1, on the ends of the valve V (co-operating with ports F, F1 and G, which feed the air for balancing the valve) and passages



E3 leading from the interior of the auxiliary cylinders to the grooves on either side of the central collar Z. The collars Z, S and S1, and the outer walls of the auxiliary cylinders E, E1, are of uniform diameter, the valve being thrown to one side or other by the admission of live air to the end face and interior of one of the auxiliary cylinders E, E1, through passages F, or F1 and E2 and E3. (*Accepted October 22, 1919.*)

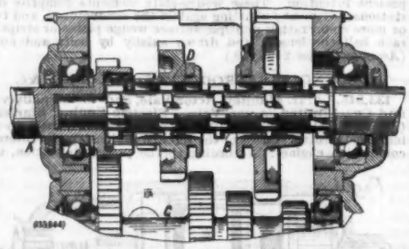
MOTOR ROAD VEHICLES.

133,567. C. Baynes, Mitcham. Motor-Car Radiators. (1 *Fig.*) January 21, 1919.—This invention relates to radiators of the type in which the water to be cooled is caused to flow through very narrow passages which are exposed to the cooling effect of a current of air. According to this invention, a radiator of the kind described is provided with transverse water passages 20



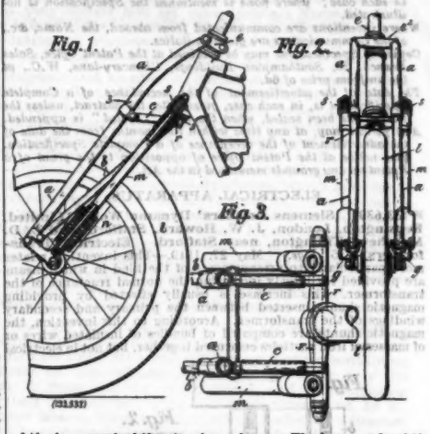
providing communication between adjacent water spaces 14, 15, any desired number of these passages may be provided at different points between the top and bottom of the chamber. Conveniently the passages are constituted by registered holes in the abutting ribs of adjacent water spaces, and if desired these holes may be fitted with eyelets, the eyelets serving to secure the two corrugated strips together. (*Accepted October 22, 1919.*)

133,544. G. E. Stanley, Coventry. Change-Speed Gears. (1 *Fig.*) December 23, 1918.—This invention relates to change-speed gears in which coaxially-mounted driving and driven shafts A, B, respectively are engaged with one another by a member D, slidable upon one of them, which member is adapted to connect them operatively, either directly, or by the aid of a gear formed with it to engage co-operating gears carried upon a parallelly-disposed lay shaft C in permanent engagement with the driving shaft A, and it especially refers to that type of change-speed gear in which the sliding member D in its neutral position, is rotatably free on its supporting shaft, and is provided with one or more sets of dogs adapted to engage splines upon the said shaft, and with a further set arranged to engage the co-



operating co-axially-mounted driving or driven member. According to this invention, the dogs are so arranged that the sliding member is clutched to the co-operating member in advance of its engagement with its own shaft. By this arrangement, where, as is usual, the dogs engaging the co-operating member are situated at a greater radius from their rotational axis than those which engage the shaft, the first engagement takes place with those dogs having the greater peripheral speed, and the last engagement with dogs having a lower peripheral speed, whereby the shock of the final engagement is minimised. Preferably three sets of dogs are employed on the sliding member, one set to engage the co-operating member, and the other two sets, disposed one set at each end of the sliding member, for engaging the splines on its own shaft. (*Accepted October 22, 1919.*)

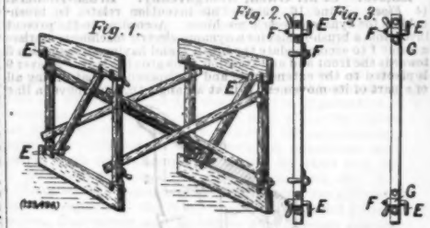
133,532. Alldays and Onions, Limited, Birmingham, and A. H. Johnson, Birmingham. Motor Cycles. (3 *Figs.*) November 30, 1918.—The improved spring fork constituting the invention comprises a rigid girder frame *a*, *b*, *c*, attached at its upper end to the opposite ends of a short horizontal stay or tube *a*2, on the slip *s*, at the upper end of the steering column, the other end of the girder frame terminating in front of the hub of the steering wheel *l*, the spindle of which is fixed in slots or holes in a pair of links *g*, or short levers, pivoted to the lower ends of the rigid girder frame. The lower end of the steering column is also connected to the rigid girder frame by a short crossing tube or stay and a pair of struts. The two arms *m*, or branches of the steering fork, are tubular, and they are provided with bushes at their upper ends by which they are pivoted to the ends of a crossing spindle *r* projecting from the opposite sides



of the lower end of the steering column. The lower ends of the arms or branches of the steering fork bear on coiled springs *n* arranged on guiding rods or tubes pivoted to the pair of links *g*, or short levers, by which the spindle of the front wheel is connected to the rigid girder frame, the said guiding rods or tubes extending through the tubular arms *m* or branches of the steering wheel fork and projecting from the upper ends of the same, the said upper ends having upon them other coiled springs *s* or buffers. (*Accepted October 22, 1919.*)

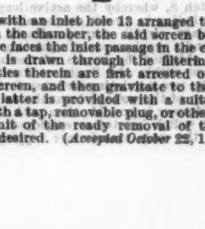
MISCELLANEOUS.

133,496. P. Yorke, London, and the Standard Building Construction Company, Limited, London. Scaffolding. (3 *Figs.*) November 2, 1918.—This invention relates to scaffolding. According to this invention, screw clips are provided which hook over the edges of and connect together a series of horizontal and oblique scaffold members. These clips each consist of a claw or hook E that is mounted at one end of a screw bolt which extends through an eye or sleeve G adapted to be secured to a scaffold member *e.g.* by means of wood screws or by bolts extending through holes in the scaffold member with nuts or their ends. The claw or hook E is adapted to be brought into engagement with another scaffold member and then by



means of a fly or wing nut F screwed on to the other or free end of the bolt the two scaffold members are drawn slightly against each other, so as to hold them firmly in their relative positions. For example, the eyes or sleeves may be secured to vertically or obliquely-arranged scaffold members, the horizontal member being flat boards arranged edgewise, one a suitable distance vertically above the other, each pair being connected by two vertical members and an oblique member. Two of the vertical frames so formed may be connected by four oblique members, this type of scaffolding being obviously extensible indefinitely either in a horizontal or a vertical direction. (*Accepted October 22, 1919.*)

133,497. E. C. Proctor, Sparkbrook, Birmingham. Liquid Filtering Devices. (3 *Figs.*) November 4, 1918.—This invention relates more particularly to a device or apparatus intended for use in filtering or straining petrol. The invention consists in the employment, in a suitable chamber or receptacle 1 having at opposite sides thereof inlet and outlet passages 7, 8, respectively for the liquid, of a filtering screen 11 mounted diagonally therein and secured to or on the upper inclined face of a cylindrical body part or tubing 12, which is adapted to be readily inserted in or removed from its position in the chamber,



and is provided with an inlet hole 13 arranged to align with the inlet passage 7 in the chamber, the said screen being so disposed that its underside faces the inlet passage in the chamber, so that when the liquid is drawn through the filtering chamber, the solids or impurities therein are first arrested on the underside of the filtering screen, and then gravitate to the bottom of the chamber, which latter is provided with a suitable opening or outlet 3 fitted with a tap, removable plug, or other suitable means adapted to permit of the ready removal of the accumulated impurities when desired. (*Accepted October 22, 1919.*)